FIG. 1

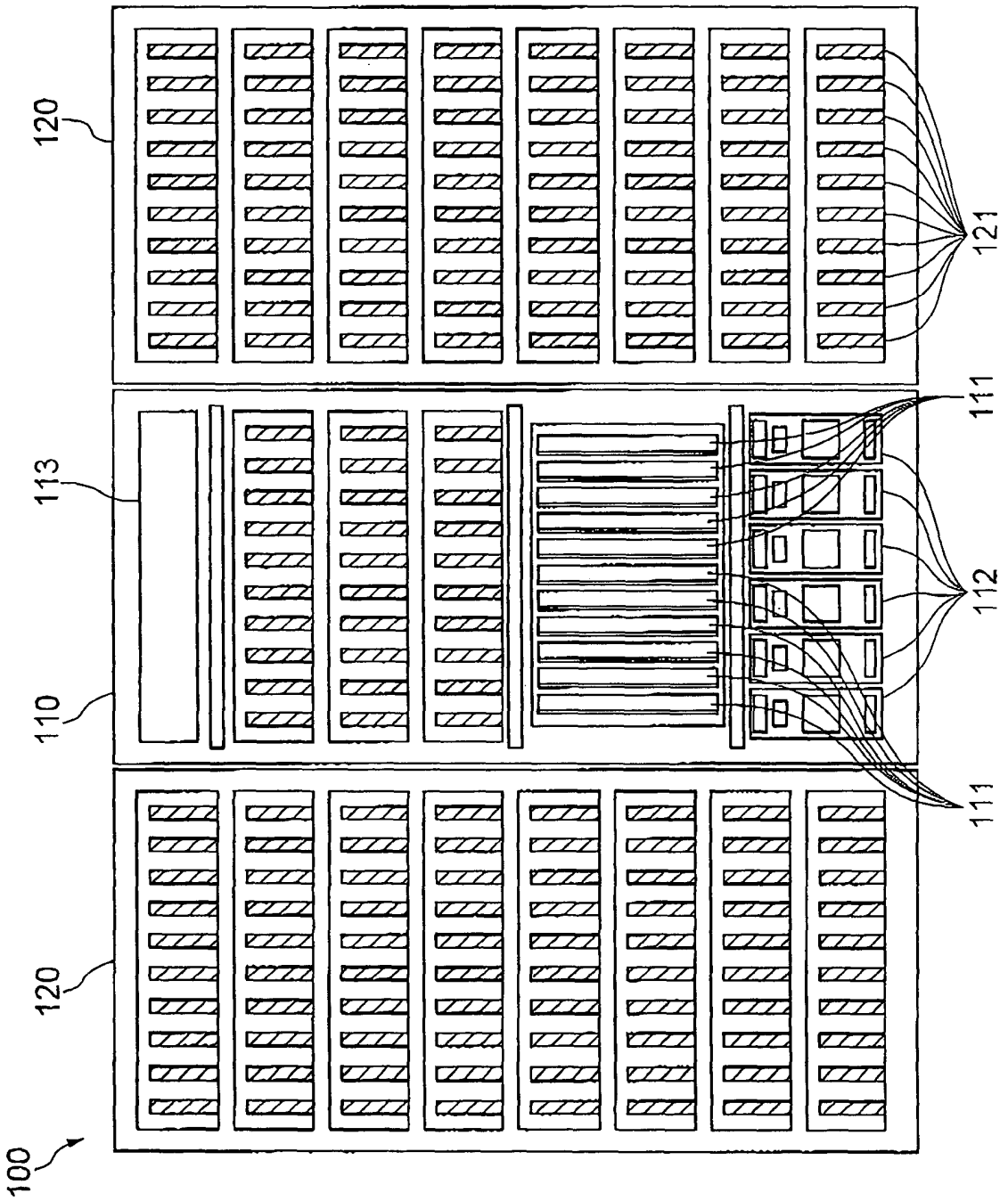


FIG. 2

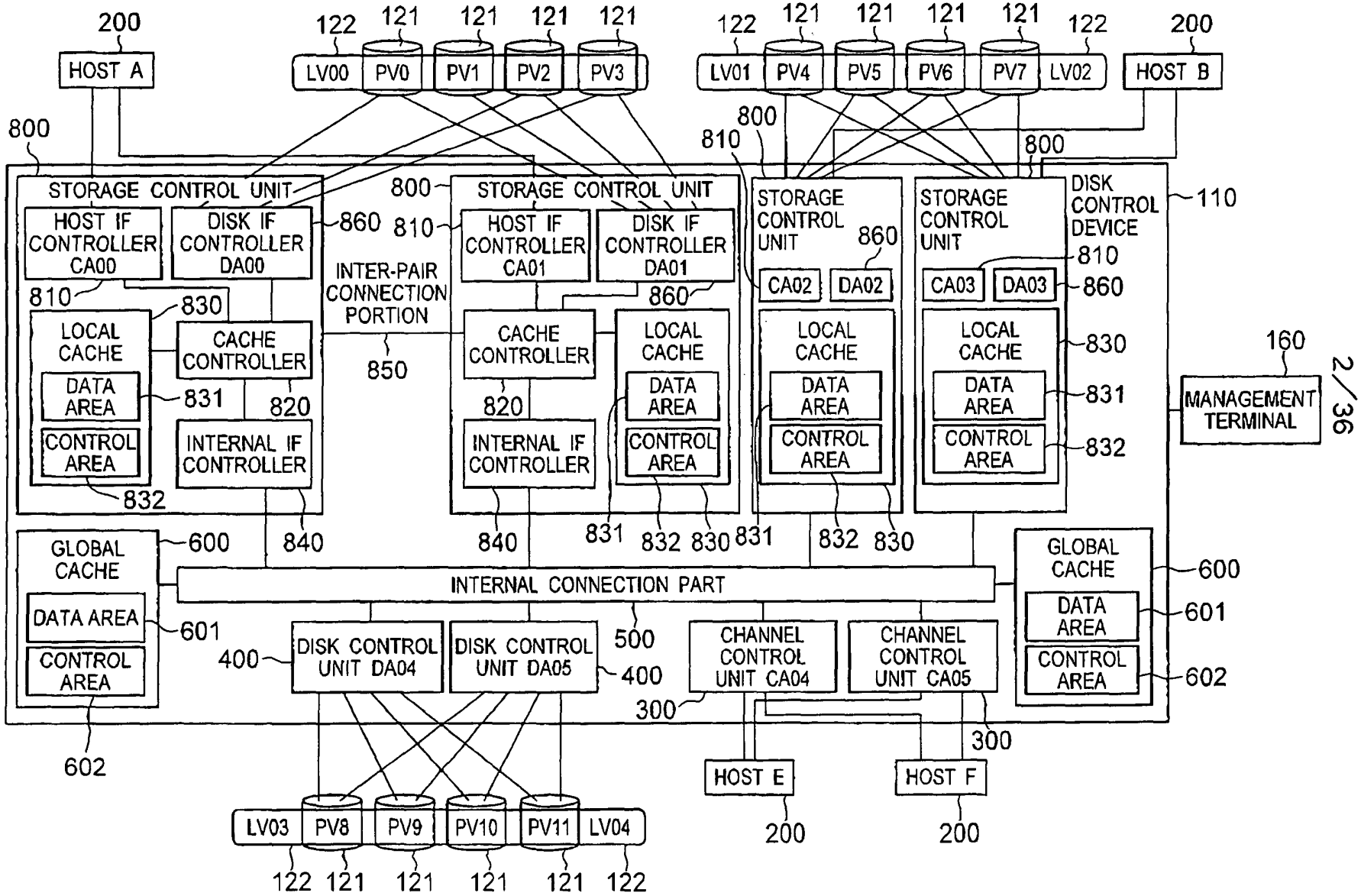

HOST A
HOST B
LV00
PV0
PV1
PV2
PV3
LV01
PV4
PV5
PV6
PV7
LV02
LV03
PV8
PV9
PV10
PV11
LV04
HOST E
HOST F
STORAGE CONTROL UNIT
HOST IF CONTROLLER CA00
DISK IF CONTROLLER DA00
HOST IF CONTROLLER CA01
DISK IF CONTROLLER DA01
CA02
DA02
CA03
DA03
INTER-PAIR CONNECTION PORTION
LOCAL CACHE
DATA AREA
CONTROL AREA
CACHE CONTROLLER
INTERNAL IF CONTROLLER
DISK CONTROL DEVICE
MANAGEMENT TERMINAL
GLOBAL CACHE
INTERNAL CONNECTION PART
DISK CONTROL UNIT DA04
DISK CONTROL UNIT DA05
CHANNEL CONTROL UNIT CA04
CHANNEL CONTROL UNIT CA05
200
800
810
820
830
831
832
840
850
860
600
601
602
400
500
300
110
160
122
121

FIG. 3

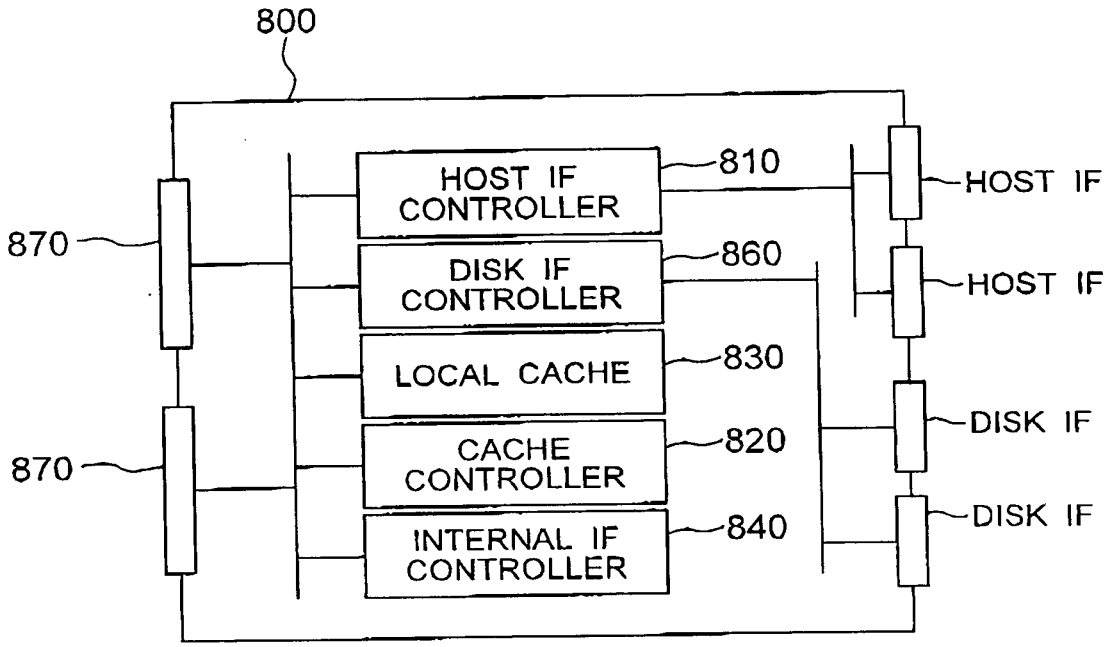

800
HOST IF CONTROLLER
810
DISK IF CONTROLLER
860
LOCAL CACHE
830
CACHE CONTROLLER
820
INTERNAL IF CONTROLLER
840
870
870
HOST IF
HOST IF
DISK IF
DISK IF

FIG. 4

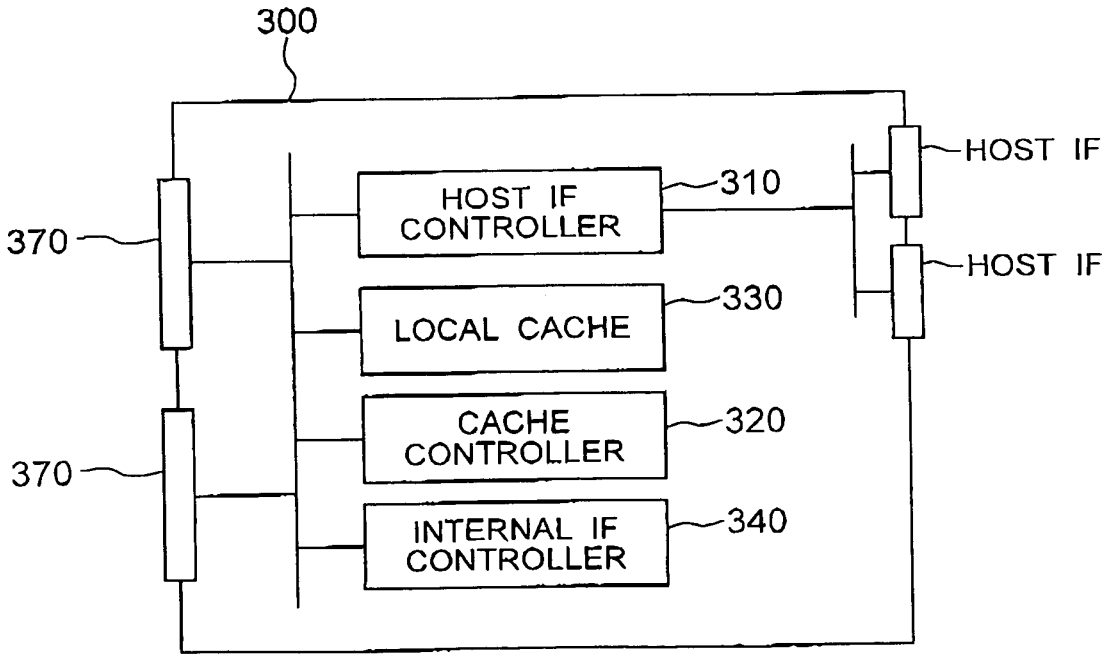

300
HOST IF CONTROLLER
310
LOCAL CACHE
330
CACHE CONTROLLER
320
INTERNAL IF CONTROLLER
340
370
370
HOST IF
HOST IF

FIG. 5

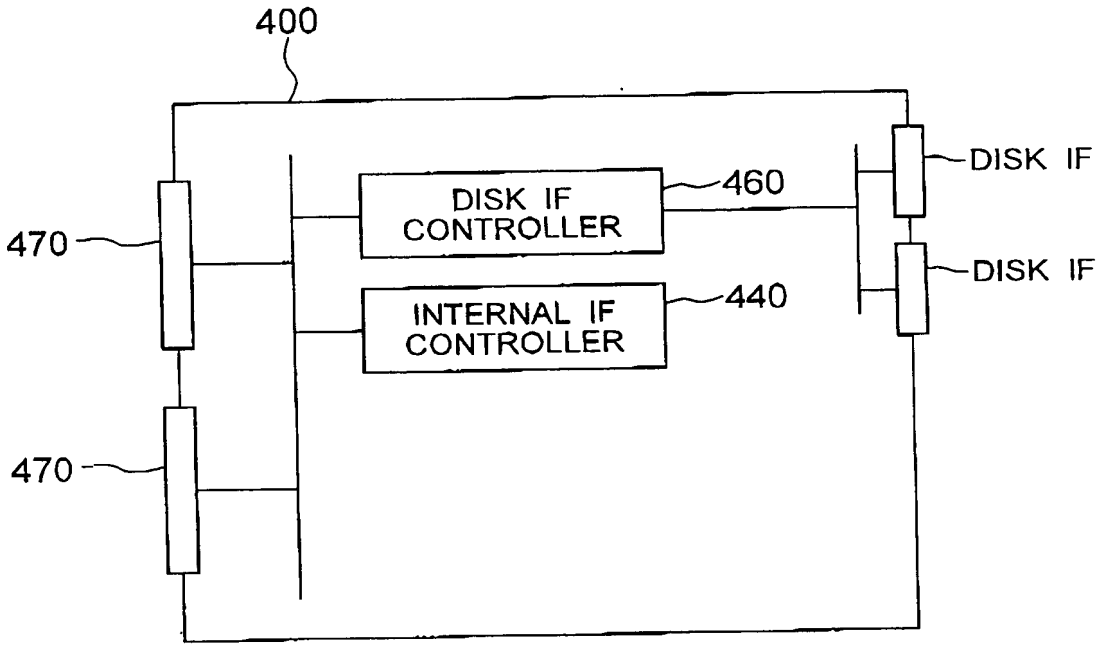

400
DISK IF CONTROLLER
460
DISK IF
DISK IF
470
INTERNAL IF CONTROLLER
440
470

FIG. 6

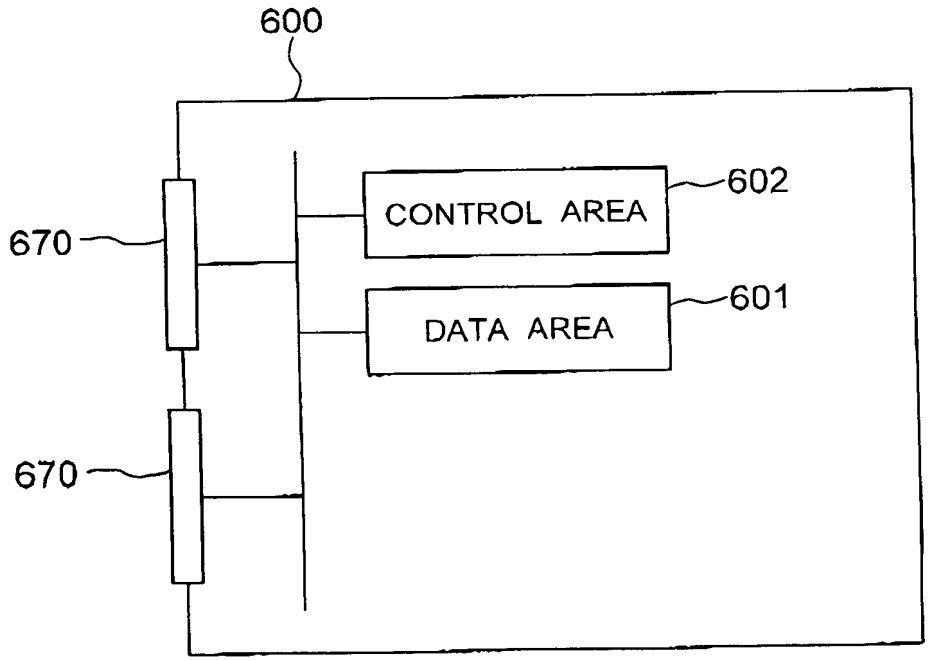

600
CONTROL AREA
602
670
DATA AREA
601
670

FIG. 7

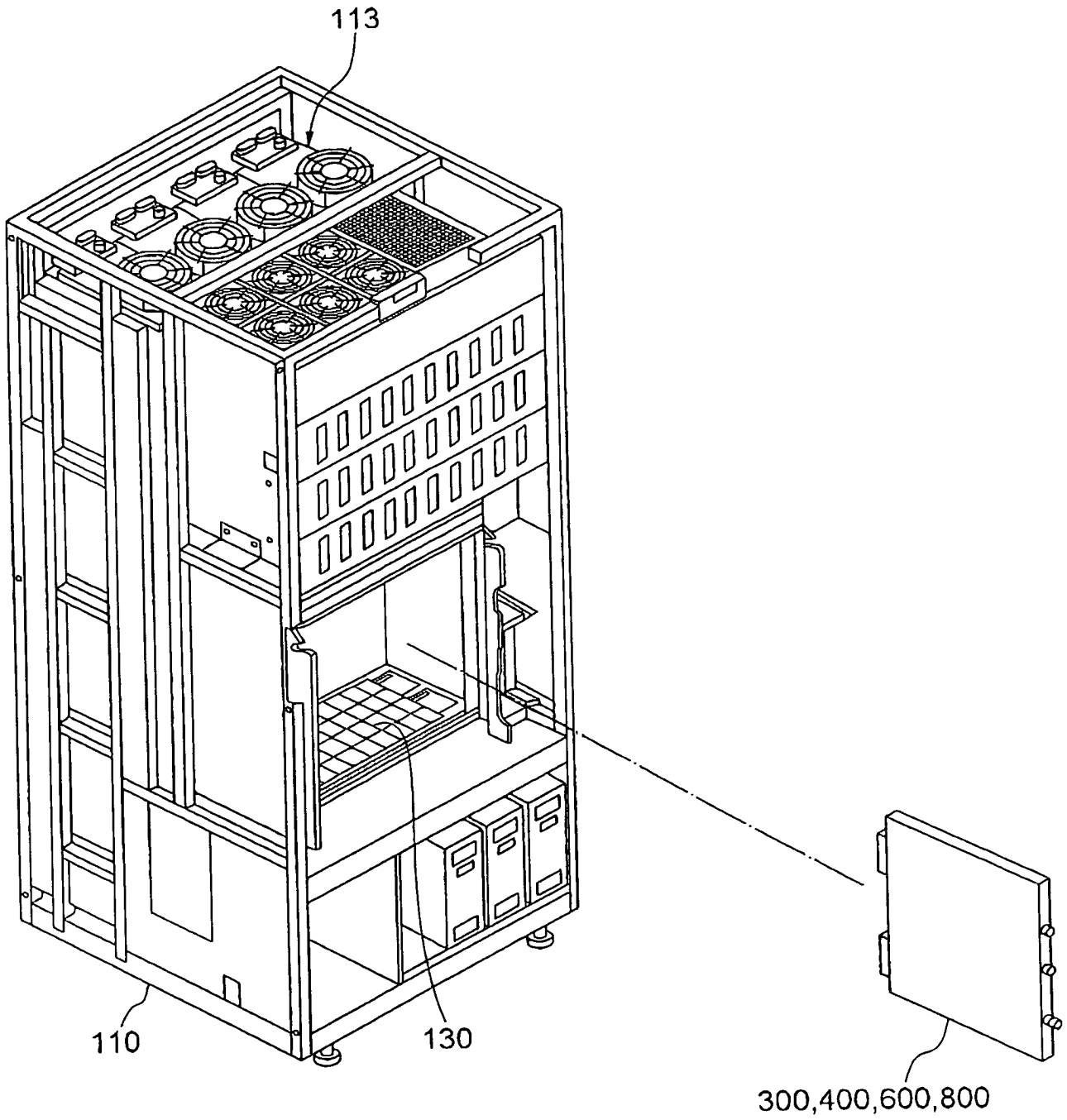


FIG. 8

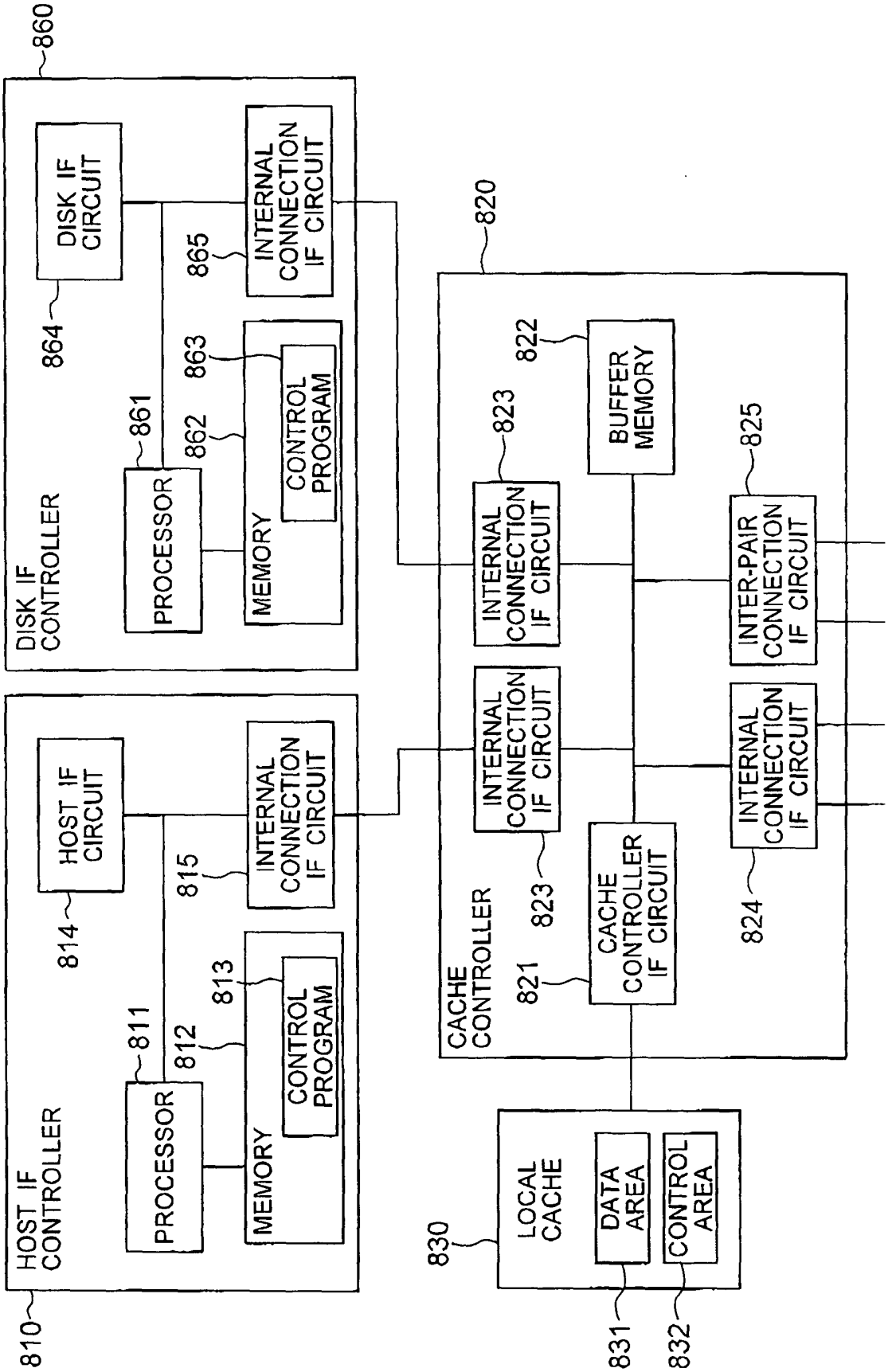

860
DISK IF CONTROLLER
DISK IF CIRCUIT
INTERNAL CONNECTION IF CIRCUIT
PROCESSOR
MEMORY
CONTROL PROGRAM
861
862
863
864
865
820
CACHE CONTROLLER
BUFFER MEMORY
822
INTERNAL CONNECTION IF CIRCUIT
823
CACHE CONTROLLER IF CIRCUIT
821
INTER-PAIR CONNECTION IF CIRCUIT
825
824
HOST IF CONTROLLER
HOST IF CIRCUIT
INTERNAL CONNECTION IF CIRCUIT
PROCESSOR
MEMORY
CONTROL PROGRAM
811
812
813
814
815
810
830
LOCAL CACHE
DATA AREA
CONTROL AREA
831
832

FIG. 9

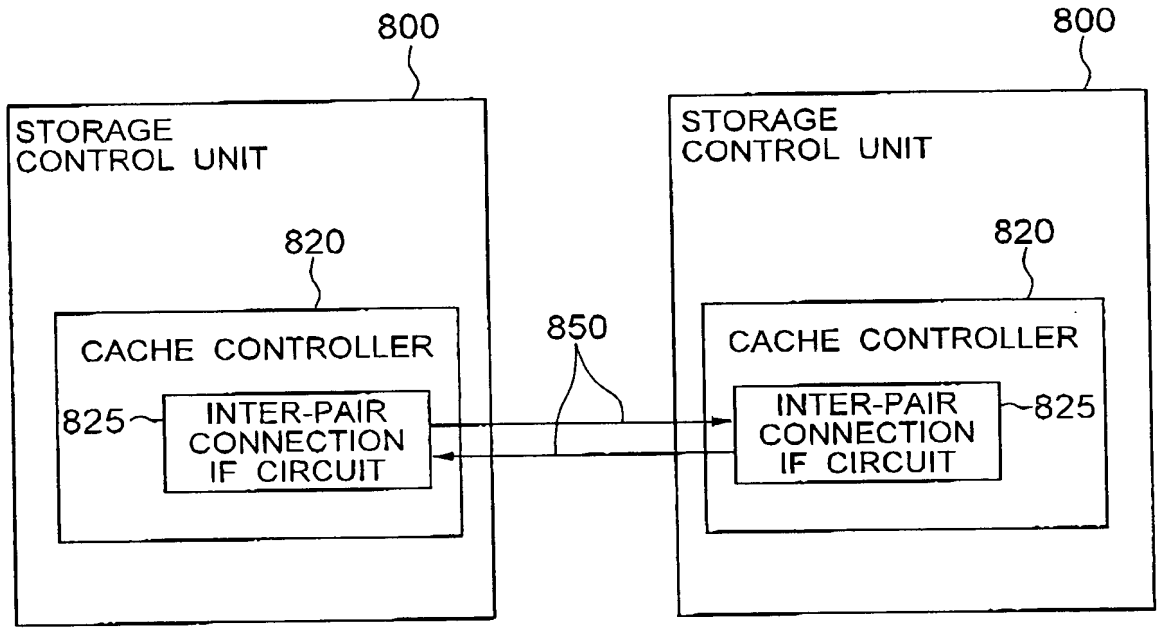

800
800
STORAGE CONTROL UNIT
STORAGE CONTROL UNIT
820
820
CACHE CONTROLLER
CACHE CONTROLLER
850
825
INTER-PAIR CONNECTION IF CIRCUIT
INTER-PAIR CONNECTION IF CIRCUIT
825

FIG. 10

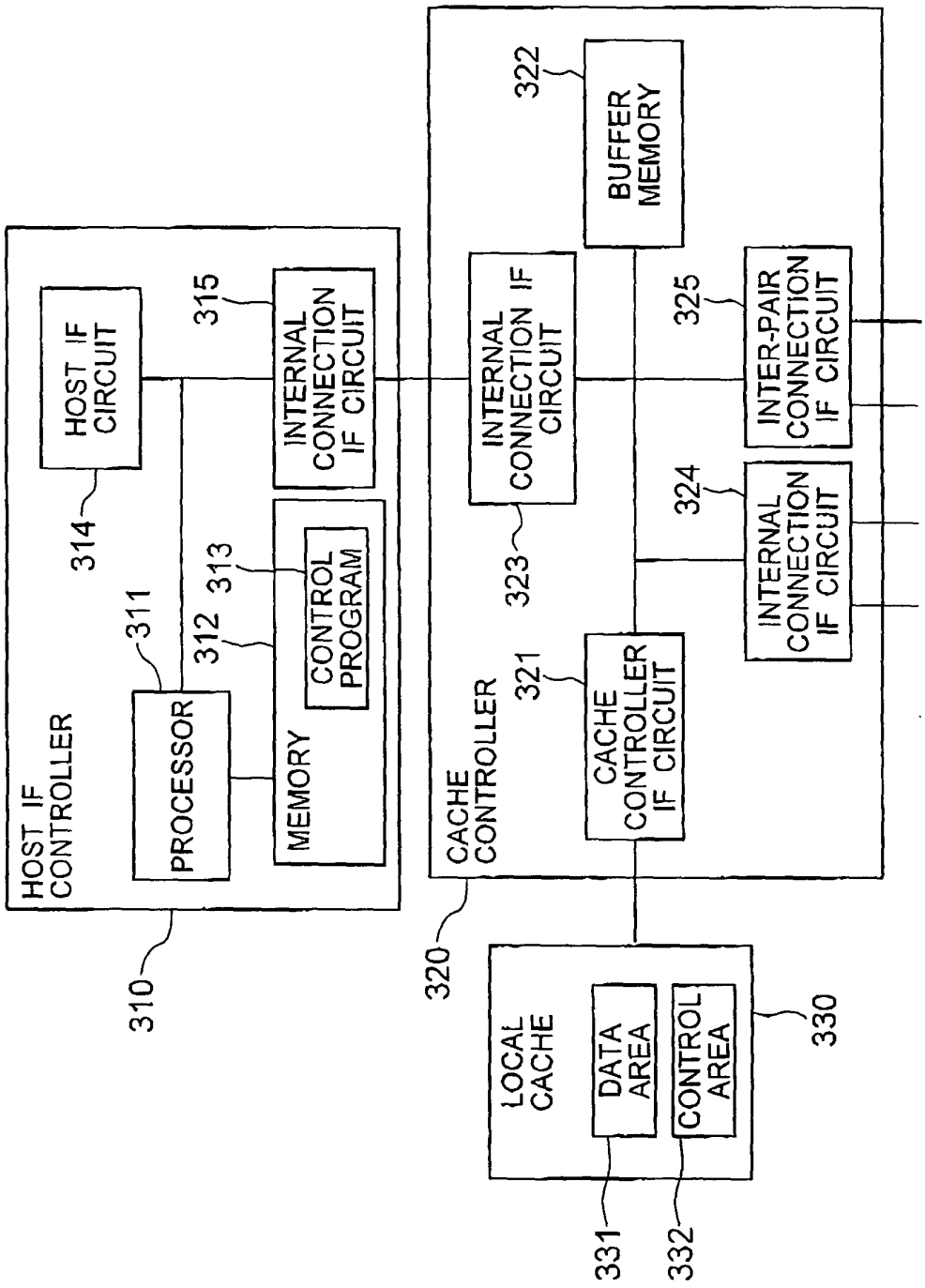

HOST IF CONTROLLER
HOST IF CIRCUIT
INTERNAL CONNECTION IF CIRCUIT
PROCESSOR
MEMORY
CONTROL PROGRAM
310
311
312
313
314
315
CACHE CONTROLLER
INTERNAL CONNECTION IF CIRCUIT
BUFFER MEMORY
CACHE CONTROLLER IF CIRCUIT
INTER-PAIR CONNECTION IF CIRCUIT
INTERNAL CONNECTION IF CIRCUIT
320
321
322
323
324
325
LOCAL CACHE
DATA AREA
CONTROL AREA
330
331
332

FIG. 11

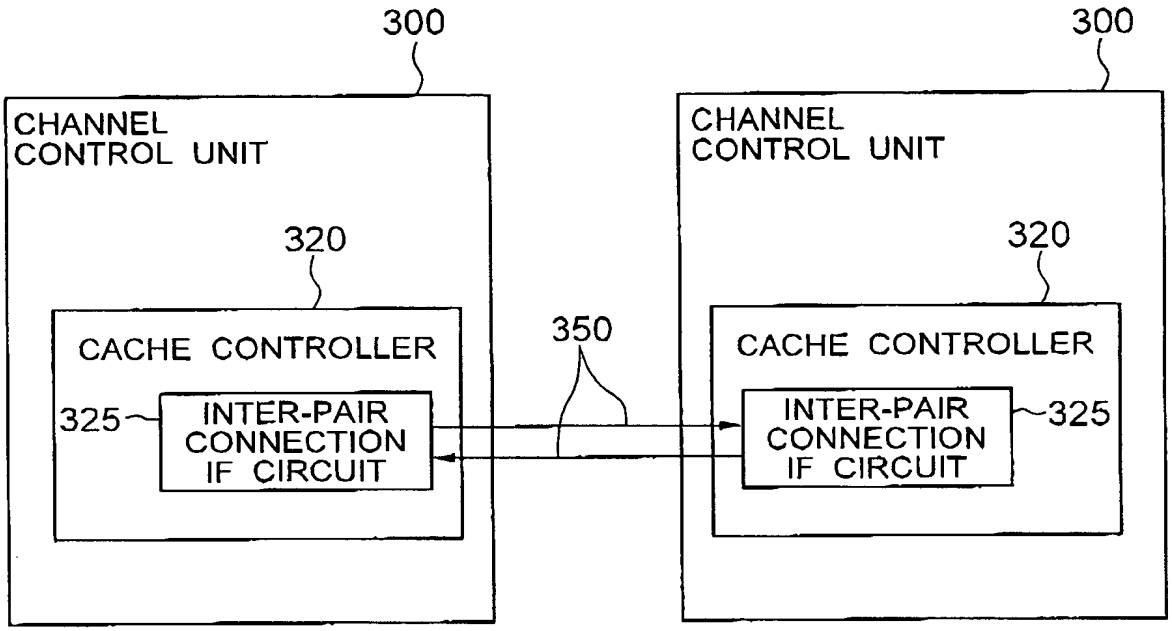

300
300
CHANNEL CONTROL UNIT
CHANNEL CONTROL UNIT
320
320
CACHE CONTROLLER
CACHE CONTROLLER
350
325
INTER-PAIR CONNECTION IF CIRCUIT
INTER-PAIR CONNECTION IF CIRCUIT
325

FIG. 12

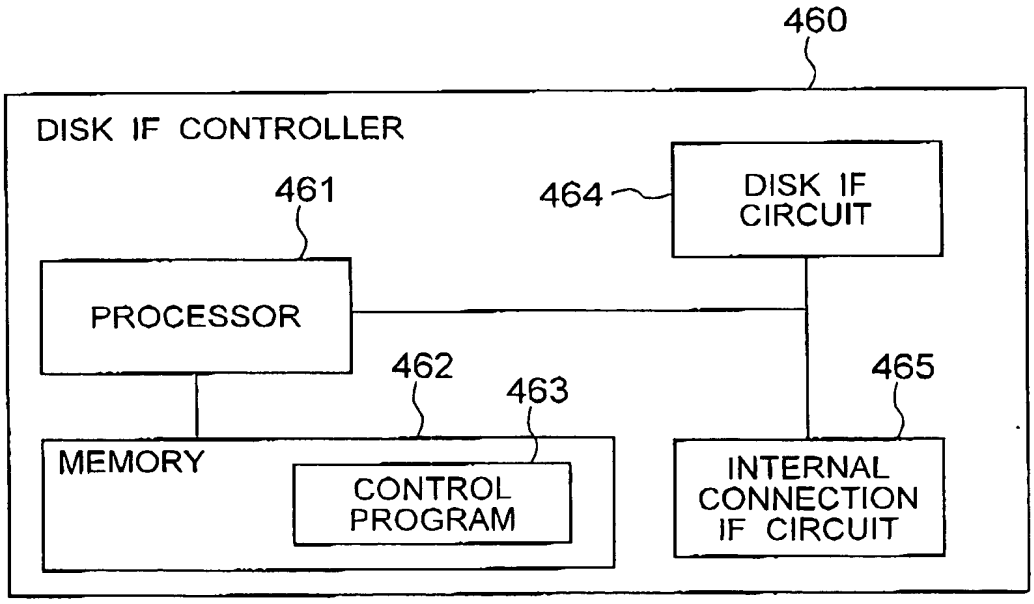

460
DISK IF CONTROLLER
461
464
DISK IF CIRCUIT
PROCESSOR
462
463
465
MEMORY
CONTROL PROGRAM
INTERNAL CONNECTION IF CIRCUIT

FIG. 13

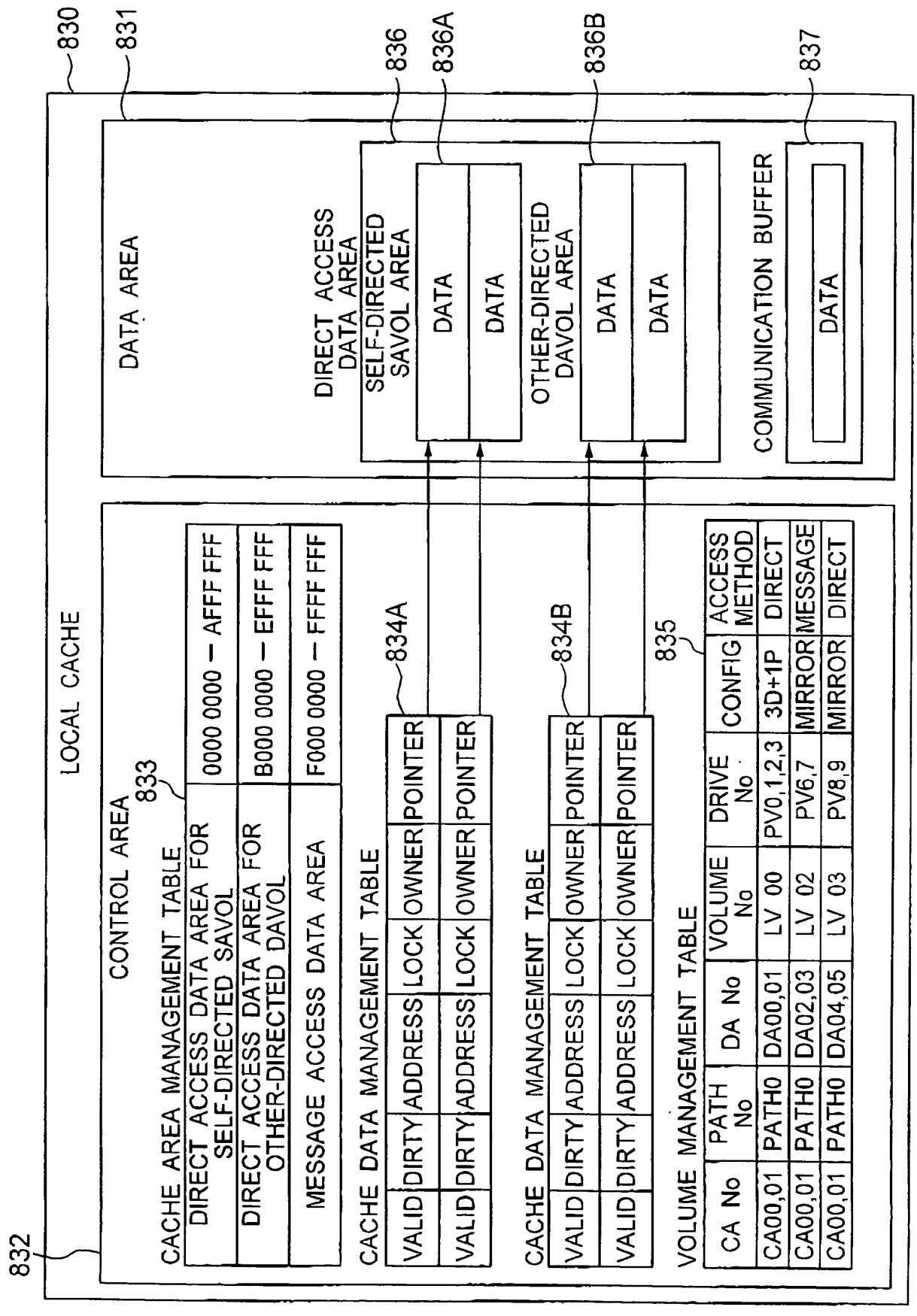

830
831
832
833
834A
834B
835
836
836A
836B
837
LOCAL CACHE
CONTROL AREA
CACHE AREA MANAGEMENT TABLE
DIRECT ACCESS DATA AREA FOR SELF-DIRECTED SAVOL
DIRECT ACCESS DATA AREA FOR OTHER-DIRECTED DAVOL
MESSAGE ACCESS DATA AREA
0000 0000 — AFFF FFF
B000 0000 — EFFF FFF
F000 0000 — FFFF FFF
CACHE DATA MANAGEMENT TABLE
VALID
DIRTY
ADDRESS
LOCK
OWNER
POINTER
CACHE DATA MANAGEMENT TABLE
VOLUME MANAGEMENT TABLE
CA No
PATH No
DA No
VOLUME No
DRIVE No
CONFIG
ACCESS METHOD
CA00,01
PATH0
DA00,01
LV 00
PV0,1,2,3
3D+1P
DIRECT
CA00,01
PATH0
DA02,03
LV 02
PV6,7
MIRROR
MESSAGE
CA00,01
PATH0
DA04,05
LV 03
PV8,9
MIRROR
DIRECT
DATA AREA
DIRECT ACCESS DATA AREA
SELF-DIRECTED SAVOL AREA
OTHER-DIRECTED DAVOL AREA
DATA
DATA
DATA
DATA
COMMUNICATION BUFFER
DATA

FIG. 14

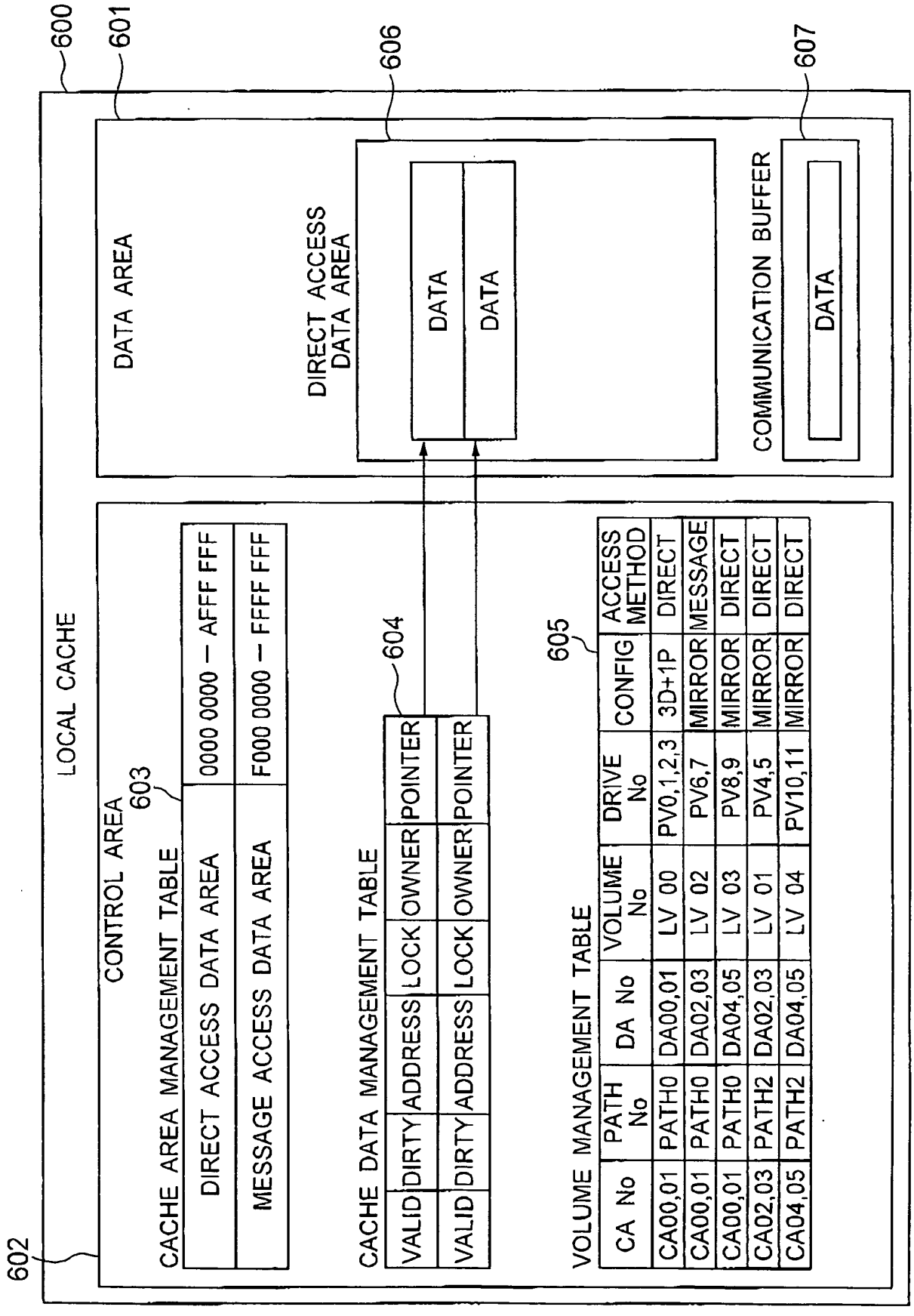

600
601
606
607
602
LOCAL CACHE
DATA AREA
DIRECT ACCESS DATA AREA
DATA
DATA
COMMUNICATION BUFFER
DATA
CONTROL AREA
603
CACHE AREA MANAGEMENT TABLE
DIRECT ACCESS DATA AREA
0000 0000 — AFFF FFF
MESSAGE ACCESS DATA AREA
F000 0000 — FFFF FFF
CACHE DATA MANAGEMENT TABLE
604
VALID DIRTY ADDRESS LOCK OWNER POINTER
VALID DIRTY ADDRESS LOCK OWNER POINTER
605
VOLUME MANAGEMENT TABLE
CA No | PATH No | DA No | VOLUME No | DRIVE No | CONFIG | ACCESS METHOD
CA00,01 | PATH0 | DA00,01 | LV 00 | PV0,1,2,3 | 3D+1P | DIRECT
CA00,01 | PATH0 | DA02,03 | LV 02 | PV6,7 | MIRROR | MESSAGE
CA00,01 | PATH0 | DA04,05 | LV 03 | PV8,9 | MIRROR | DIRECT
CA02,03 | PATH2 | DA02,03 | LV 01 | PV4,5 | MIRROR | DIRECT
CA04,05 | PATH2 | DA04,05 | LV 04 | PV10,11 | MIRROR | DIRECT

FIG. 15

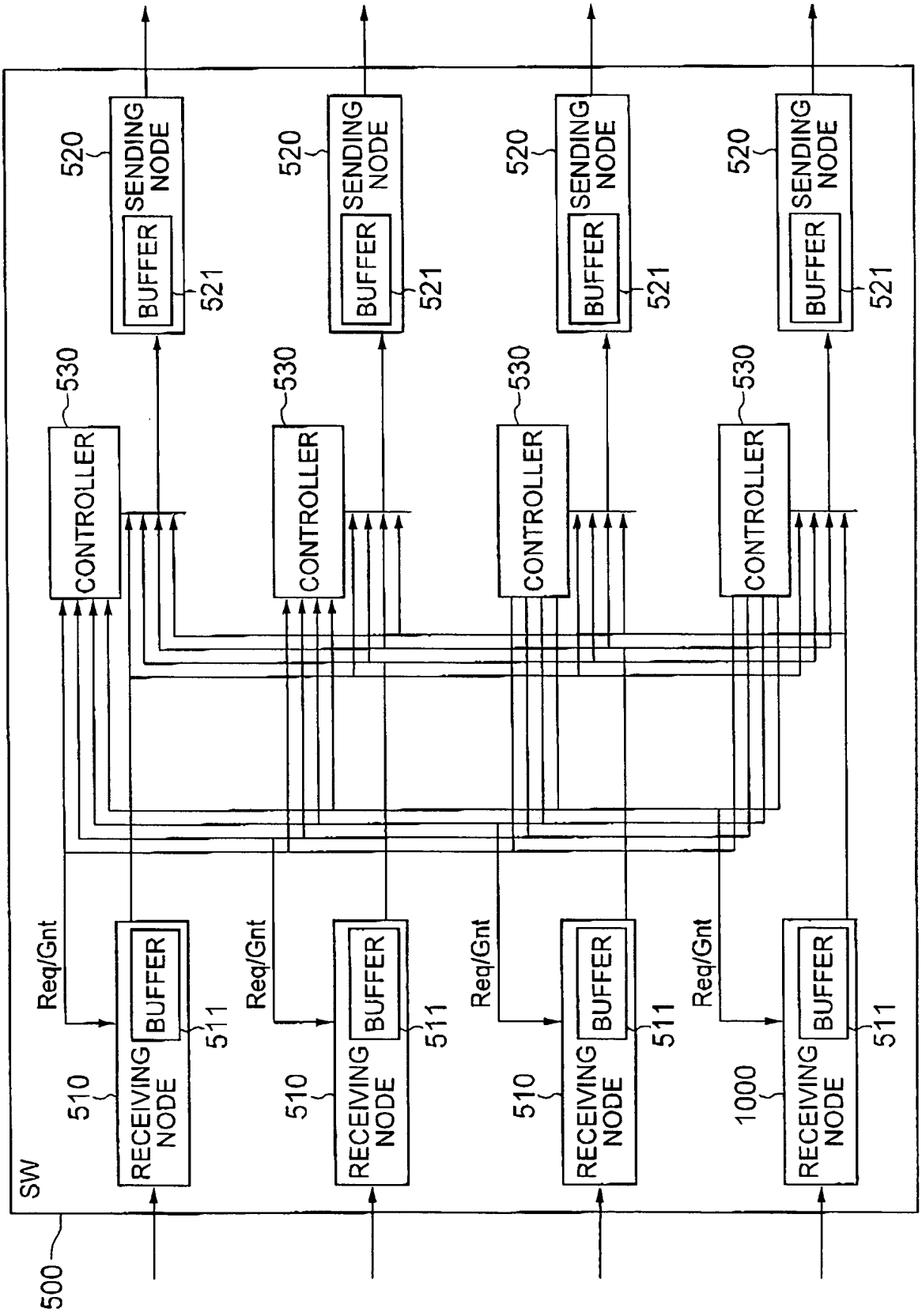

SW
500
RECEIVING NODE
510
1000
BUFFER
511
Req/Gnt
CONTROLLER
530
SENDING NODE
520
BUFFER
521

FIG. 16

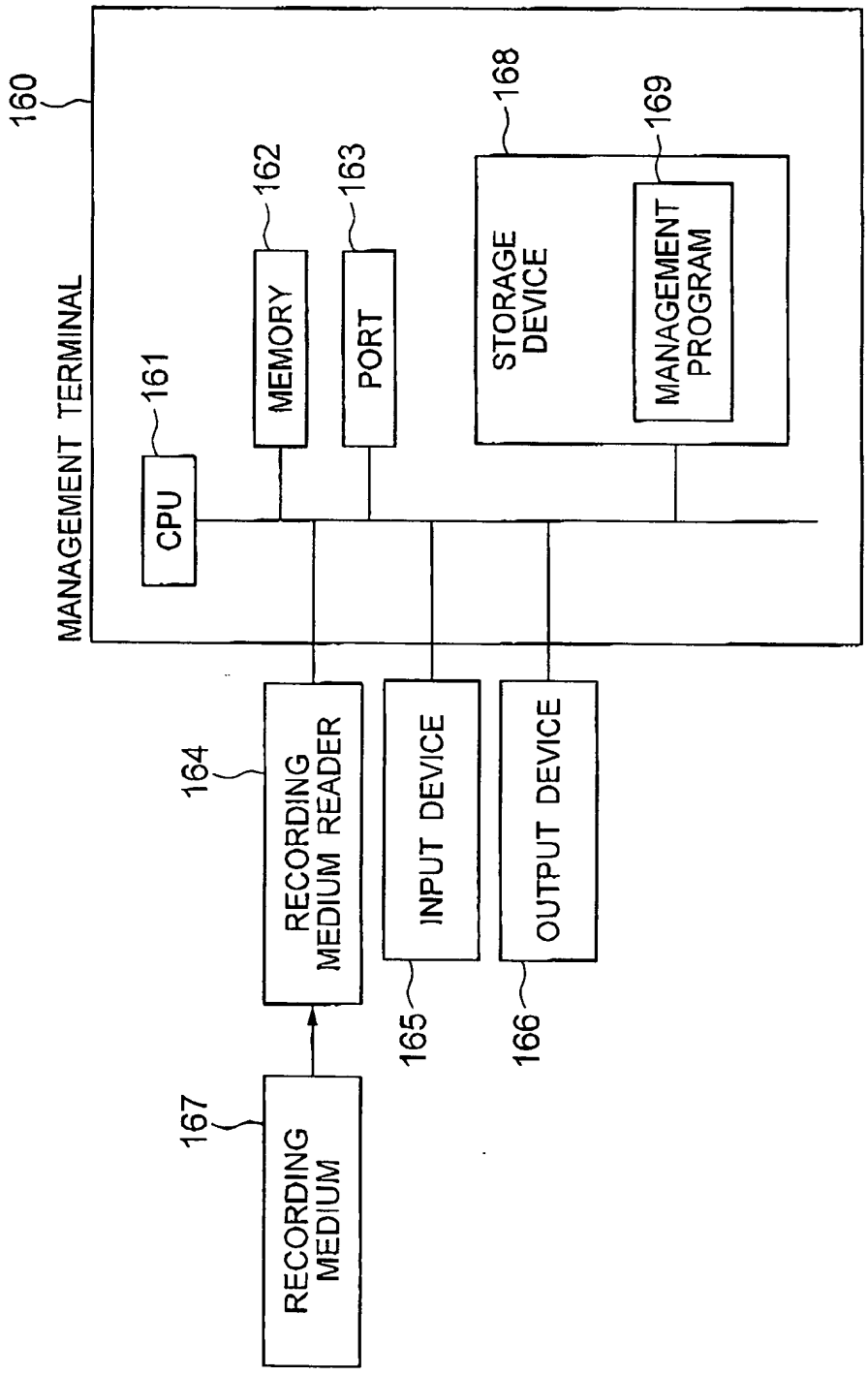

160
MANAGEMENT TERMINAL
CPU
161
MEMORY
162
PORT
163
STORAGE DEVICE
168
MANAGEMENT PROGRAM
169
RECORDING MEDIUM READER
164
INPUT DEVICE
165
OUTPUT DEVICE
166
RECORDING MEDIUM
167

FIG. 17

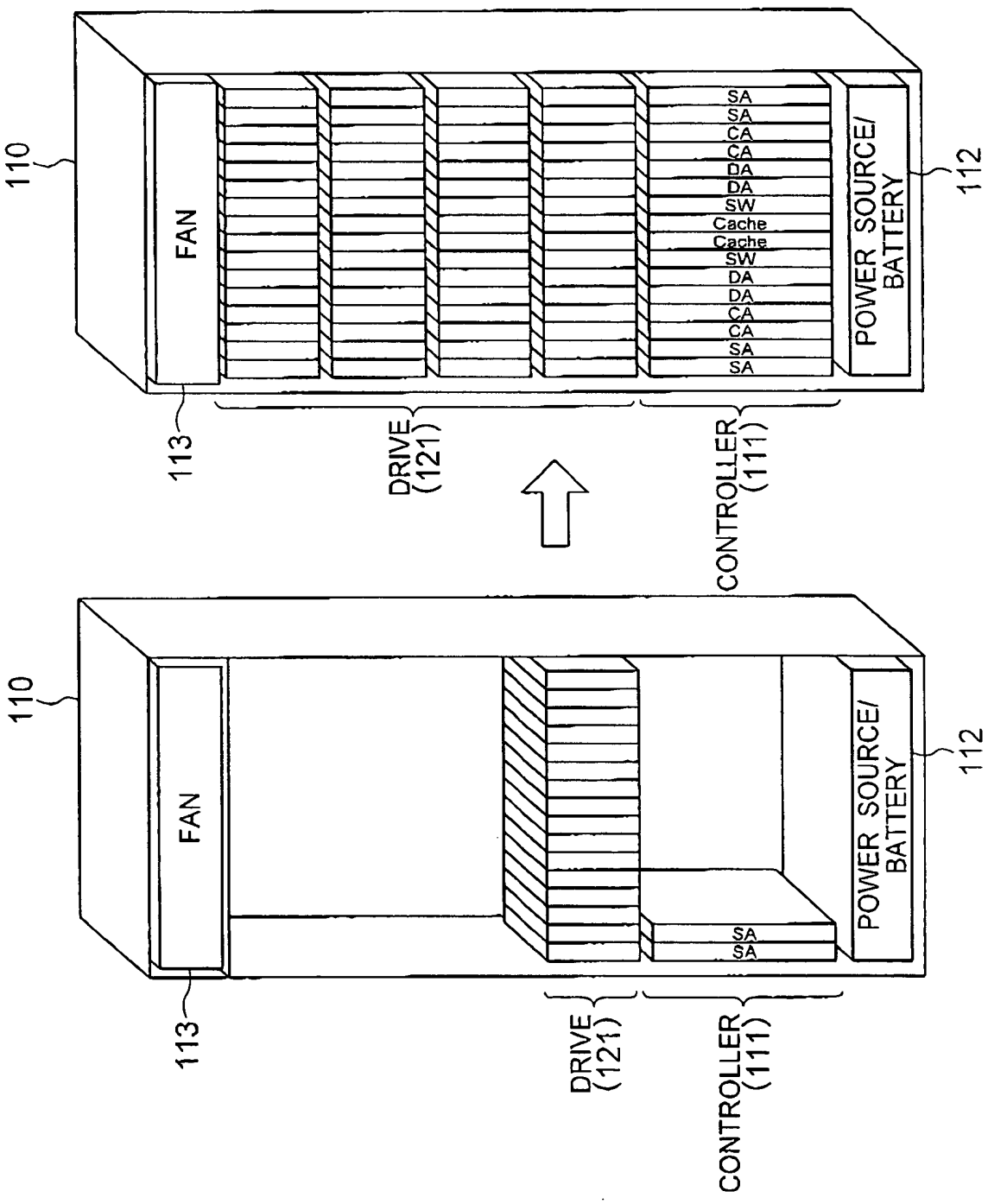

110
FAN
SA
SA
CA
CA
DA
DA
SW
Cache
Cache
SW
DA
DA
CA
CA
SA
SA
POWER SOURCE/ BATTERY
112
113
DRIVE (121)
CONTROLLER (111)
110
FAN
SA
SA
POWER SOURCE/ BATTERY
112
113
DRIVE (121)
CONTROLLER (111)

FIG. 18

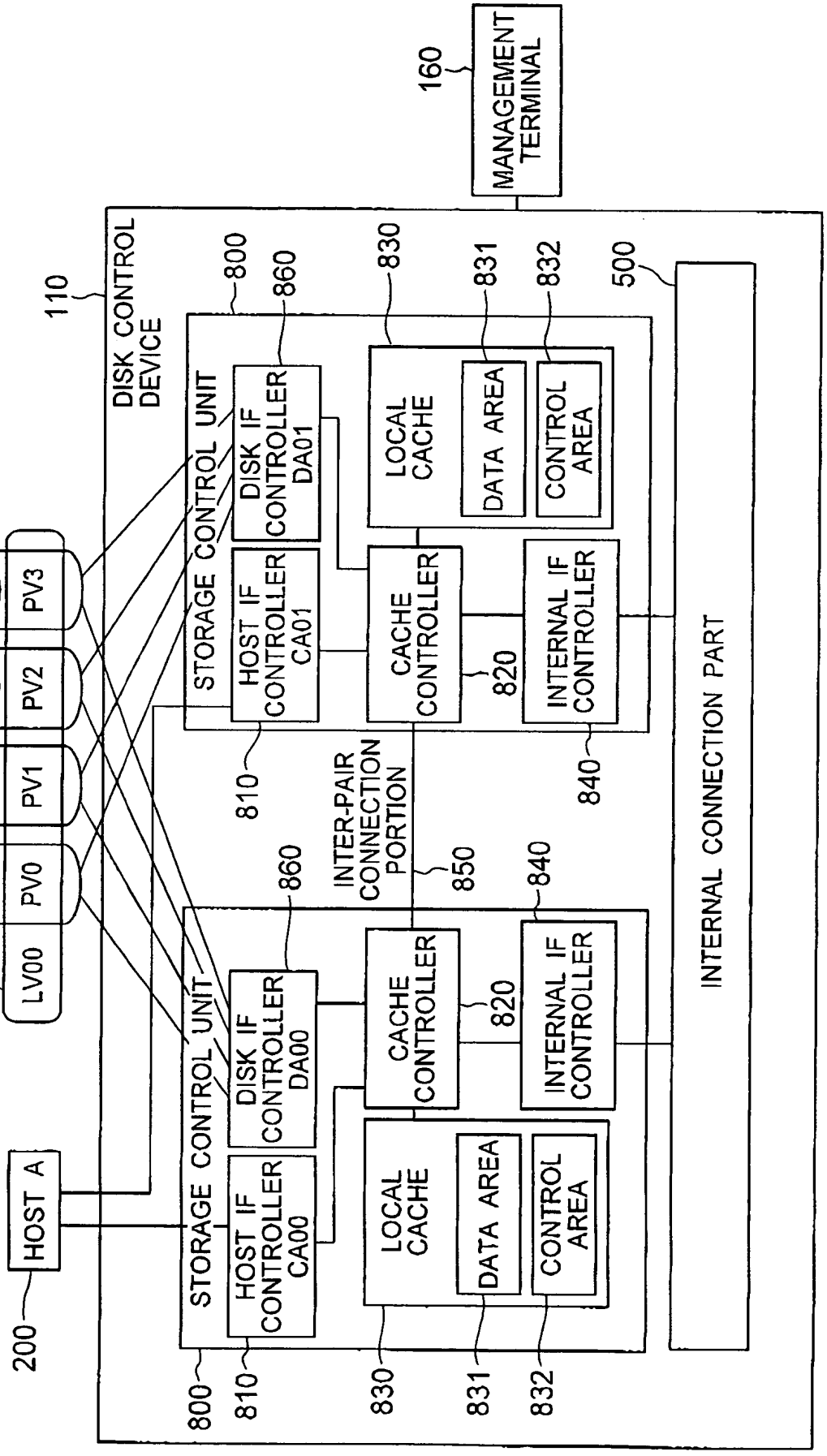

160
MANAGEMENT TERMINAL
110
DISK CONTROL DEVICE
800
860
830
831
832
500
STORAGE CONTROL UNIT
DISK IF CONTROLLER DA01
LOCAL CACHE
DATA AREA
CONTROL AREA
HOST IF CONTROLLER CA01
CACHE CONTROLLER
INTERNAL IF CONTROLLER
820
810
840
INTER-PAIR CONNECTION PORTION
850
121
PV3
PV2
PV1
PV0
122
LV00
DISK IF CONTROLLER DA00
HOST IF CONTROLLER CA00
INTERNAL CONNECTION PART
HOST A
200

FIG. 19

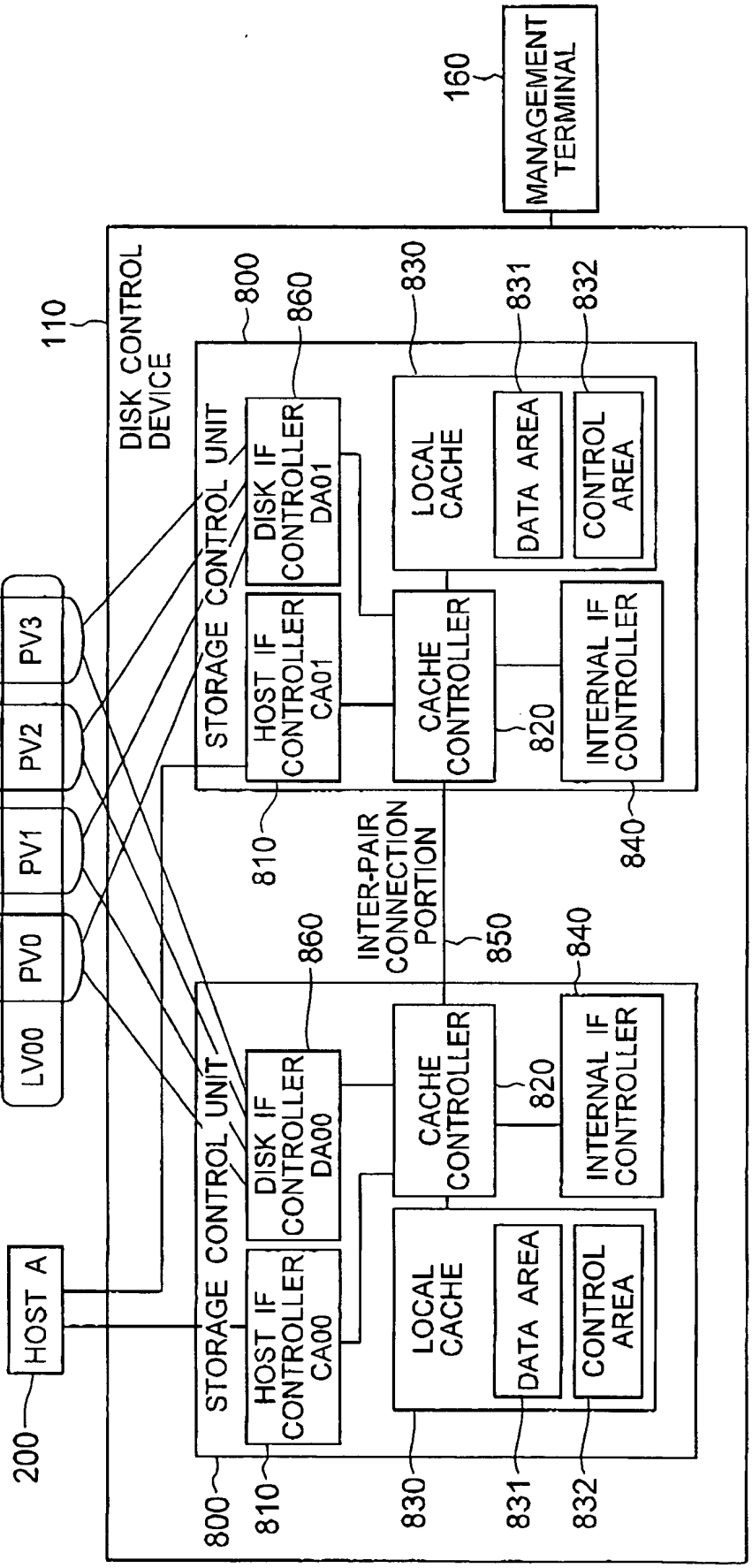

MANAGEMENT TERMINAL
160
DISK CONTROL DEVICE
110
STORAGE CONTROL UNIT
800
HOST IF CONTROLLER CA01
DISK IF CONTROLLER DA01
CACHE CONTROLLER
820
INTERNAL IF CONTROLLER
LOCAL CACHE
DATA AREA
CONTROL AREA
810
830
831
832
840
860
INTER-PAIR CONNECTION PORTION
850
HOST IF CONTROLLER CA00
DISK IF CONTROLLER DA00
HOST A
200
LV00
122
PV0
PV1
PV2
PV3
121

FIG. 20

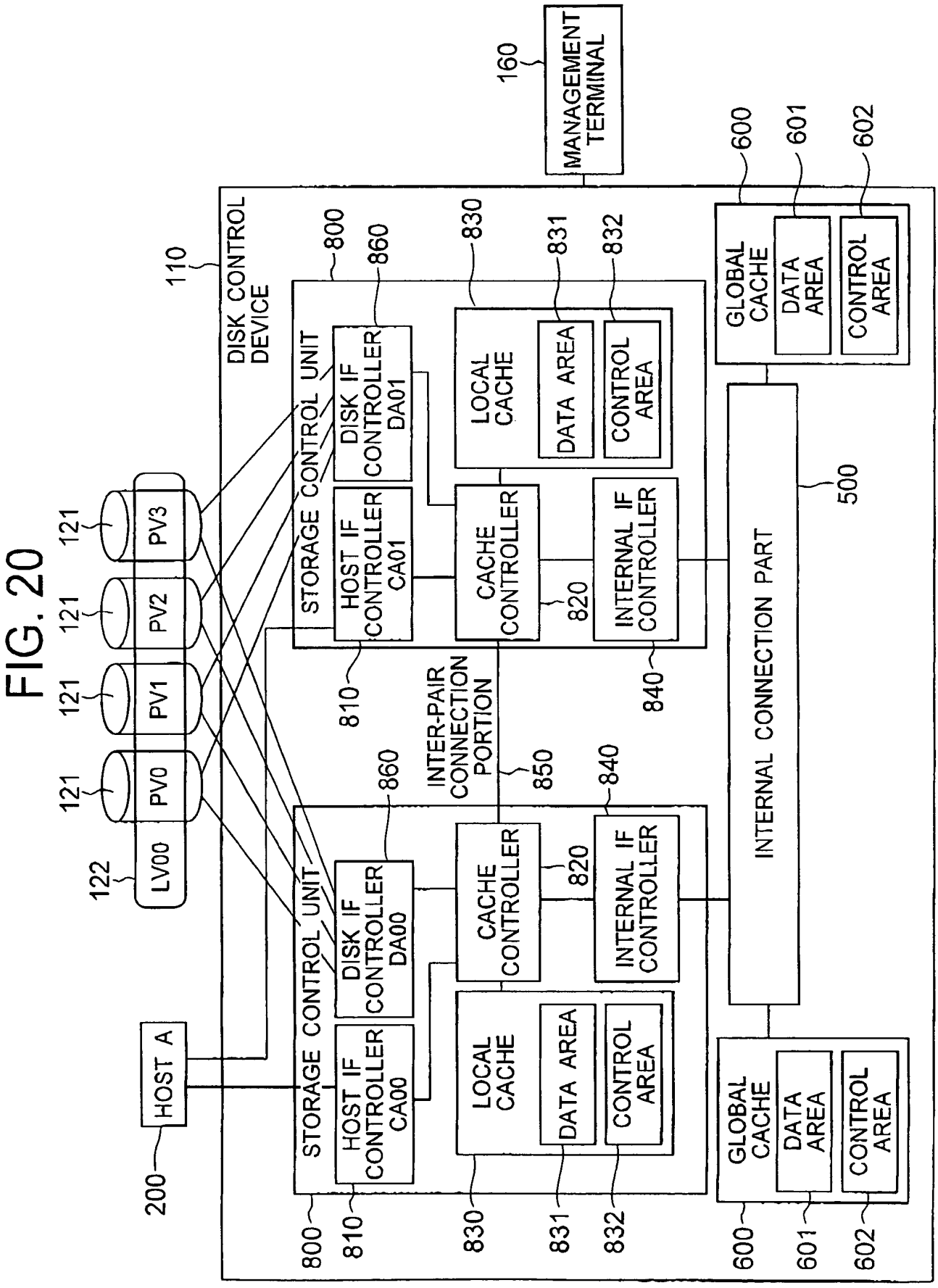

HOST A
200
MANAGEMENT TERMINAL
160
DISK CONTROL DEVICE
110
LV00
PV0
PV1
PV2
PV3
121
122
STORAGE CONTROL UNIT
HOST IF CONTROLLER CA00
DISK IF CONTROLLER DA00
HOST IF CONTROLLER CA01
DISK IF CONTROLLER DA01
800
810
860
CACHE CONTROLLER
INTER-PAIR CONNECTION PORTION
850
820
INTERNAL IF CONTROLLER
840
LOCAL CACHE
DATA AREA
CONTROL AREA
830
831
832
INTERNAL CONNECTION PART
500
GLOBAL CACHE
600
601
602

FIG. 21

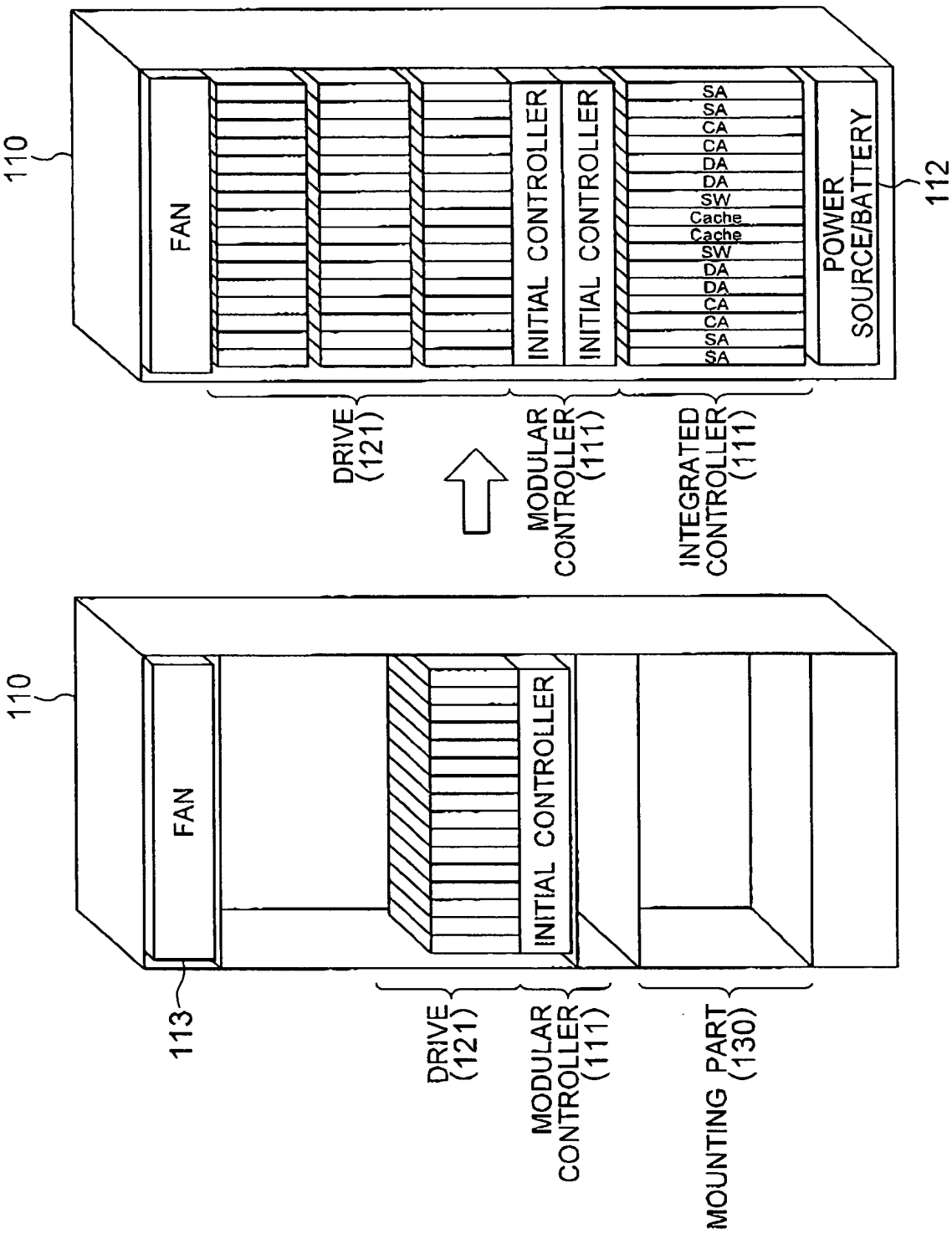
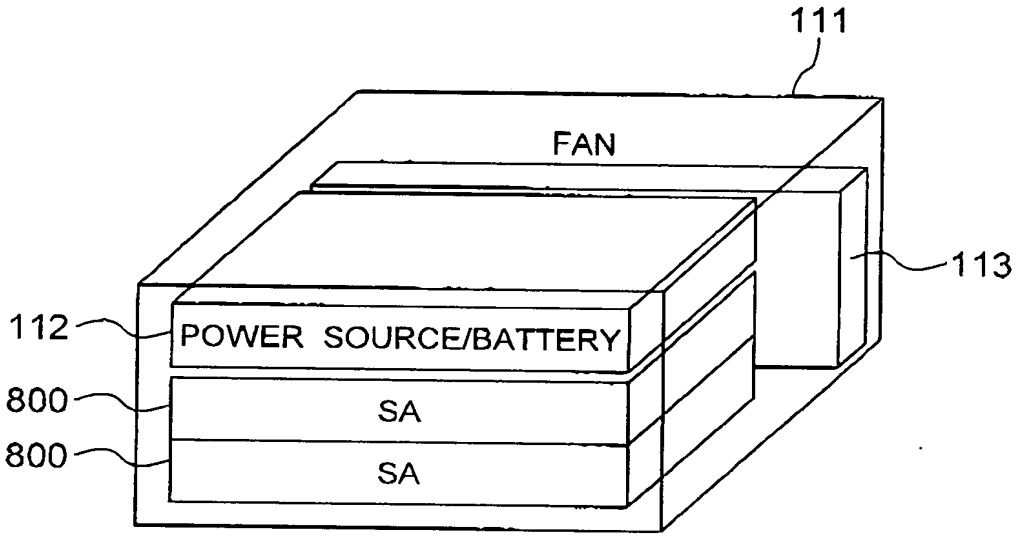

110
FAN
INITIAL CONTROLLER
INITIAL CONTROLLER
SA
SA
CA
CA
DA
DA
SW
Cache
Cache
SW
DA
DA
CA
CA
SA
SA
POWER SOURCE/BATTERY
112
DRIVE (121)
MODULAR CONTROLLER (111)
INTEGRATED CONTROLLER (111)
110
FAN
INITIAL CONTROLLER
113
DRIVE (121)
MODULAR CONTROLLER (111)
MOUNTING PART (130)

FIG. 22



INITIAL CONTROLLER
(MODULAR CONTROLLER)

FIG. 23

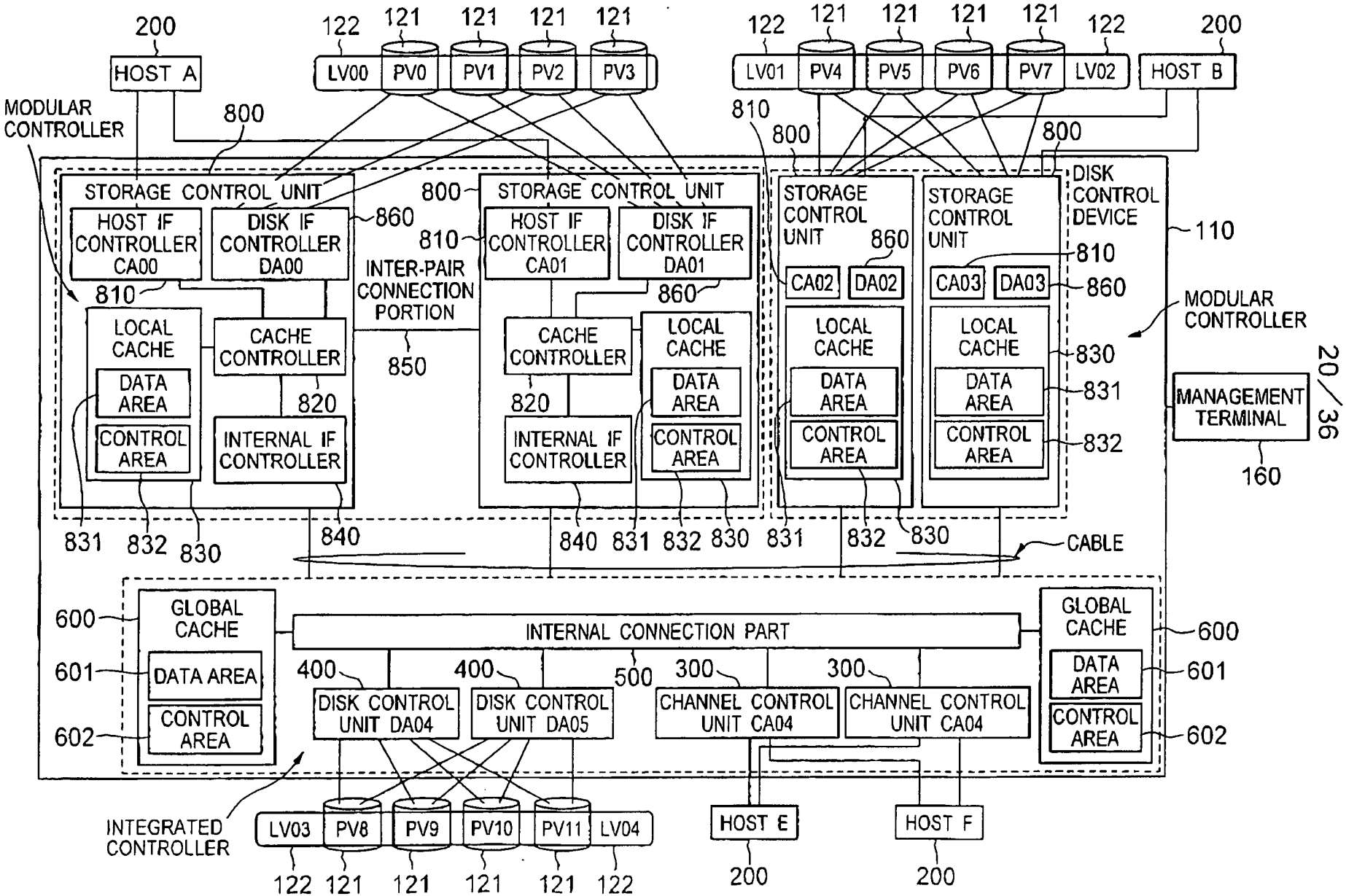

HOST A
HOST B
HOST E
HOST F
LV00
PV0
PV1
PV2
PV3
LV01
PV4
PV5
PV6
PV7
LV02
LV03
PV8
PV9
PV10
PV11
LV04
MODULAR CONTROLLER
STORAGE CONTROL UNIT
HOST IF CONTROLLER CA00
DISK IF CONTROLLER DA00
HOST IF CONTROLLER CA01
DISK IF CONTROLLER DA01
CA02
DA02
CA03
DA03
INTER-PAIR CONNECTION PORTION
LOCAL CACHE
DATA AREA
CONTROL AREA
CACHE CONTROLLER
INTERNAL IF CONTROLLER
DISK CONTROL DEVICE
MANAGEMENT TERMINAL
CABLE
GLOBAL CACHE
INTERNAL CONNECTION PART
DISK CONTROL UNIT DA04
DISK CONTROL UNIT DA05
CHANNEL CONTROL UNIT CA04
CHANNEL CONTROL UNIT CA04
INTEGRATED CONTROLLER
200
122
121
800
810
860
850
820
840
831
832
830
600
601
602
400
500
300
110
160
20/36

FIG. 24

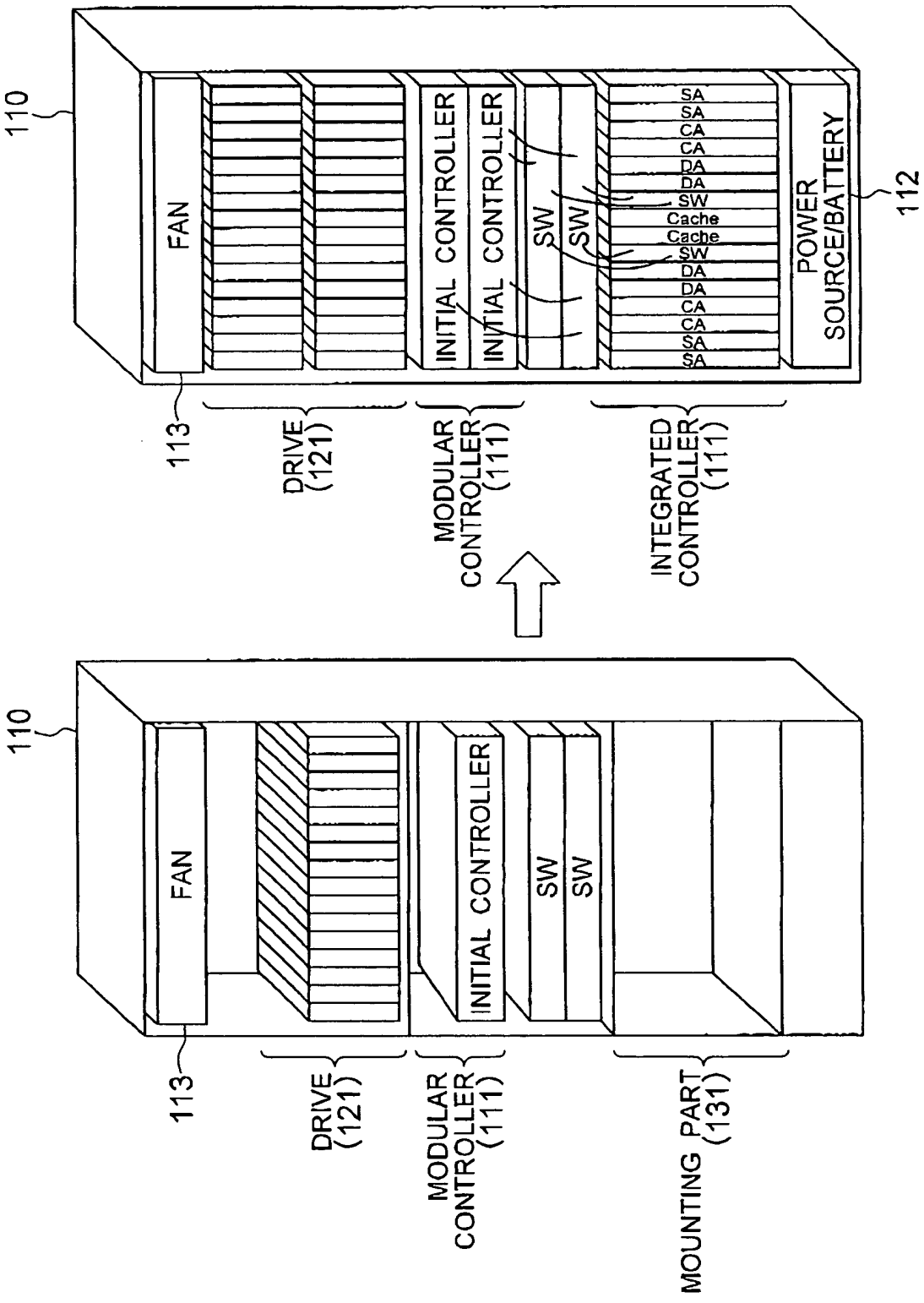

110
FAN
INITIAL CONTROLLER
INITIAL CONTROLLER
SW
SW
SA
SA
CA
CA
DA
DA
SW
Cache
Cache
SW
DA
DA
CA
CA
SA
SA
POWER SOURCE/BATTERY
112
113
DRIVE (121)
MODULAR CONTROLLER (111)
INTEGRATED CONTROLLER (111)
110
FAN
INITIAL CONTROLLER
SW
SW
113
DRIVE (121)
MODULAR CONTROLLER (111)
MOUNTING PART (131)

FIG. 25

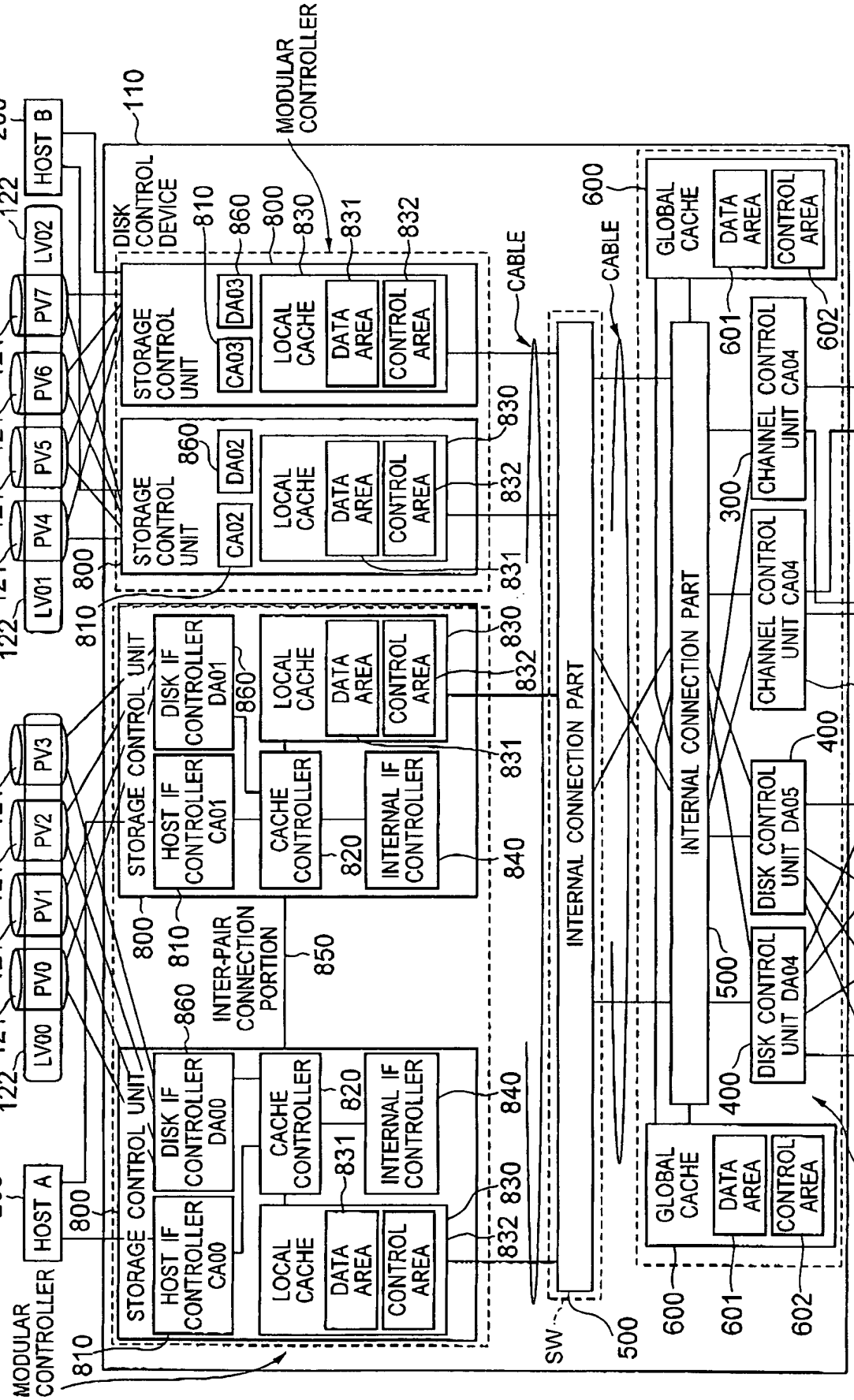

HOST A
HOST B
HOST E
HOST F
MODULAR CONTROLLER
DISK CONTROL DEVICE
STORAGE CONTROL UNIT
STORAGE CONTROL UNIT
HOST IF CONTROLLER CA00
DISK IF CONTROLLER DA00
HOST IF CONTROLLER CA01
DISK IF CONTROLLER DA01
CACHE CONTROLLER
INTERNAL IF CONTROLLER
LOCAL CACHE
DATA AREA
CONTROL AREA
INTER-PAIR CONNECTION PORTION
INTERNAL CONNECTION PART
SW
CABLE
GLOBAL CACHE
CHANNEL CONTROL UNIT CA04
DISK CONTROL UNIT DA04
DISK CONTROL UNIT DA05
INTEGRATED CONTROLLER
LV00
LV01
LV02
LV03
LV04
PV0
PV1
PV2
PV3
PV4
PV5
PV6
PV7
PV8
PV9
PV10
PV11

FIG. 26

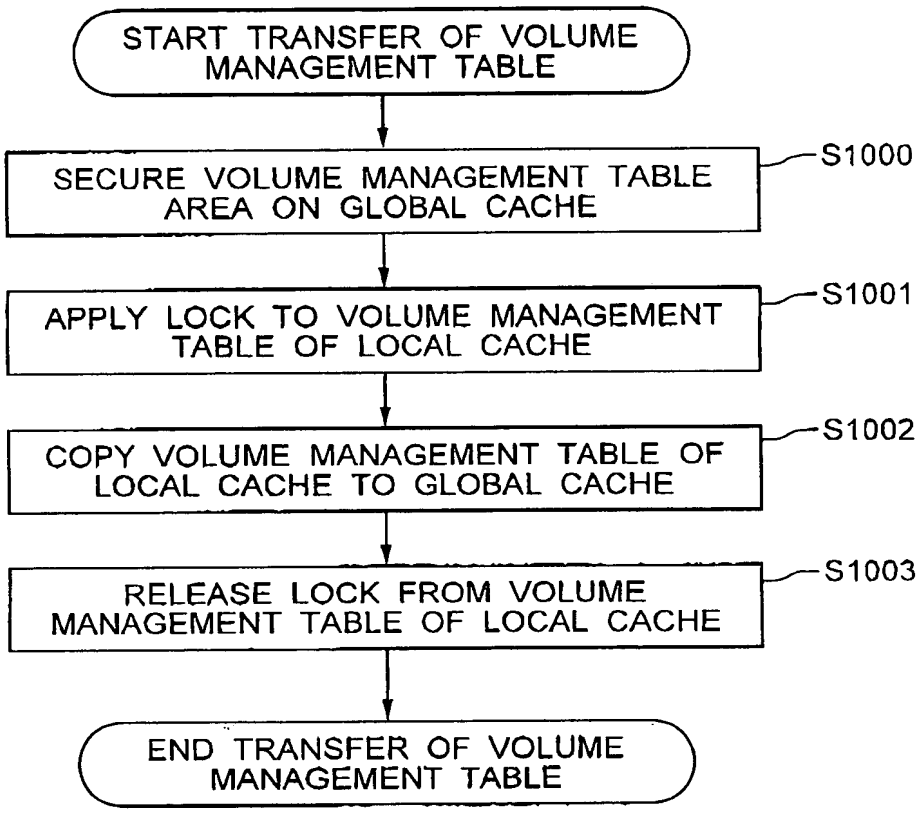

START TRANSFER OF VOLUME MANAGEMENT TABLE
SECURE VOLUME MANAGEMENT TABLE AREA ON GLOBAL CACHE
S1000
APPLY LOCK TO VOLUME MANAGEMENT TABLE OF LOCAL CACHE
S1001
COPY VOLUME MANAGEMENT TABLE OF LOCAL CACHE TO GLOBAL CACHE
S1002
RELEASE LOCK FROM VOLUME MANAGEMENT TABLE OF LOCAL CACHE
S1003
END TRANSFER OF VOLUME MANAGEMENT TABLE

FIG. 27

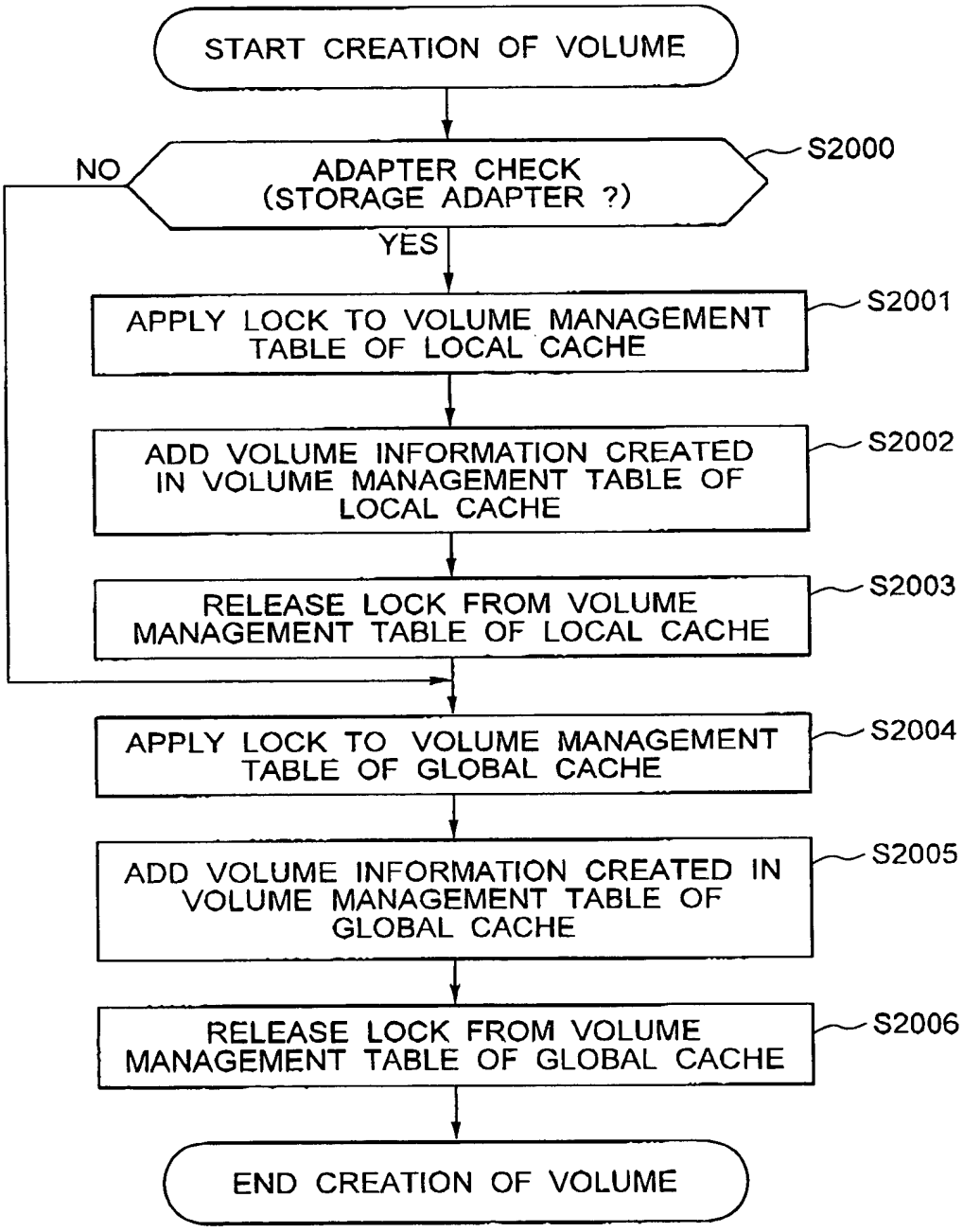

START CREATION OF VOLUME
ADAPTER CHECK (STORAGE ADAPTER ?)
S2000
NO
YES
APPLY LOCK TO VOLUME MANAGEMENT TABLE OF LOCAL CACHE
S2001
ADD VOLUME INFORMATION CREATED IN VOLUME MANAGEMENT TABLE OF LOCAL CACHE
S2002
RELEASE LOCK FROM VOLUME MANAGEMENT TABLE OF LOCAL CACHE
S2003
APPLY LOCK TO VOLUME MANAGEMENT TABLE OF GLOBAL CACHE
S2004
ADD VOLUME INFORMATION CREATED IN VOLUME MANAGEMENT TABLE OF GLOBAL CACHE
S2005
RELEASE LOCK FROM VOLUME MANAGEMENT TABLE OF GLOBAL CACHE
S2006
END CREATION OF VOLUME

FIG. 28

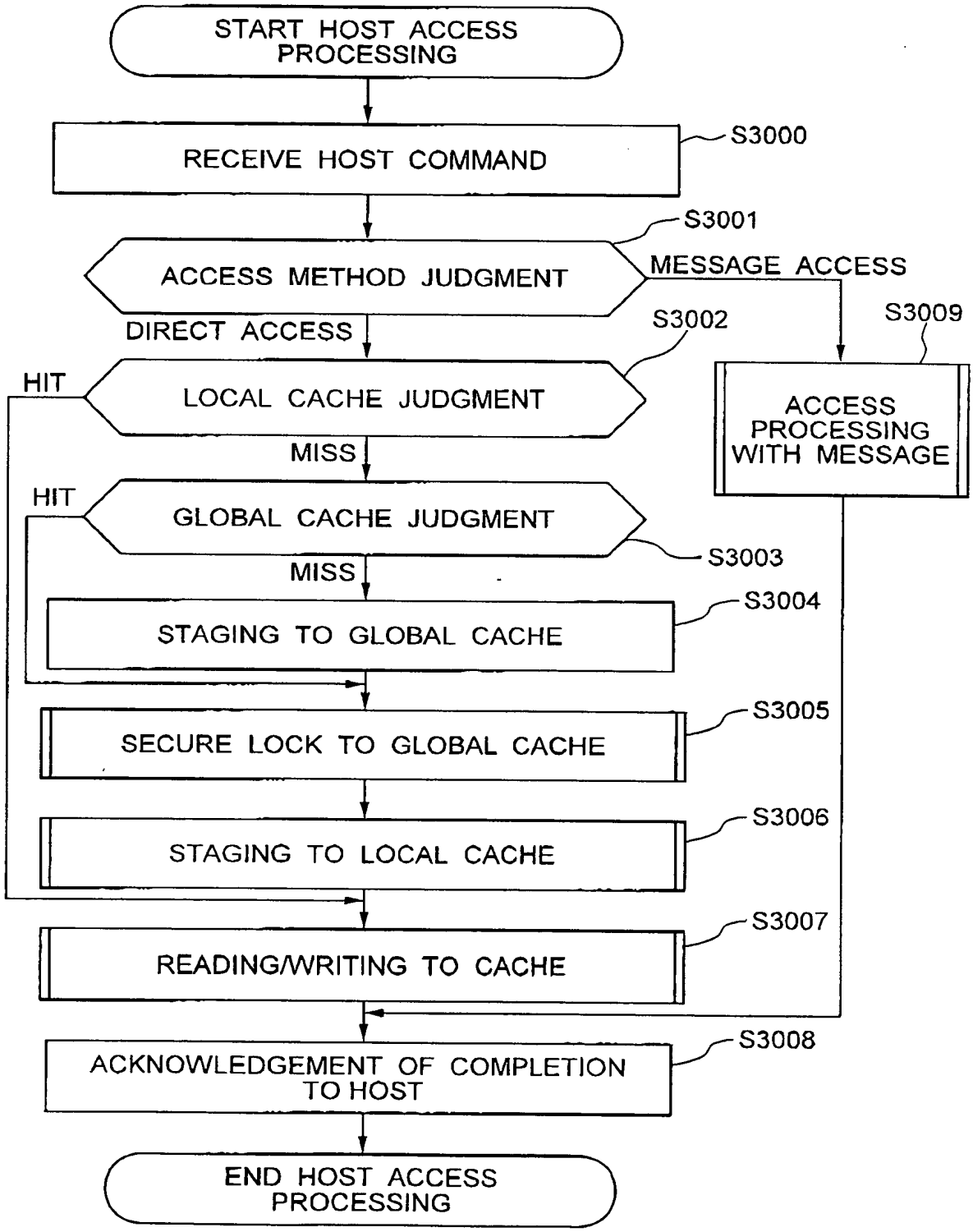

START HOST ACCESS PROCESSING
RECEIVE HOST COMMAND
S3000
S3001
ACCESS METHOD JUDGMENT
MESSAGE ACCESS
DIRECT ACCESS
S3002
S3009
HIT
LOCAL CACHE JUDGMENT
ACCESS PROCESSING WITH MESSAGE
MISS
HIT
GLOBAL CACHE JUDGMENT
S3003
MISS
S3004
STAGING TO GLOBAL CACHE
S3005
SECURE LOCK TO GLOBAL CACHE
S3006
STAGING TO LOCAL CACHE
S3007
READING/WRITING TO CACHE
S3008
ACKNOWLEDGEMENT OF COMPLETION TO HOST
END HOST ACCESS PROCESSING

FIG. 29

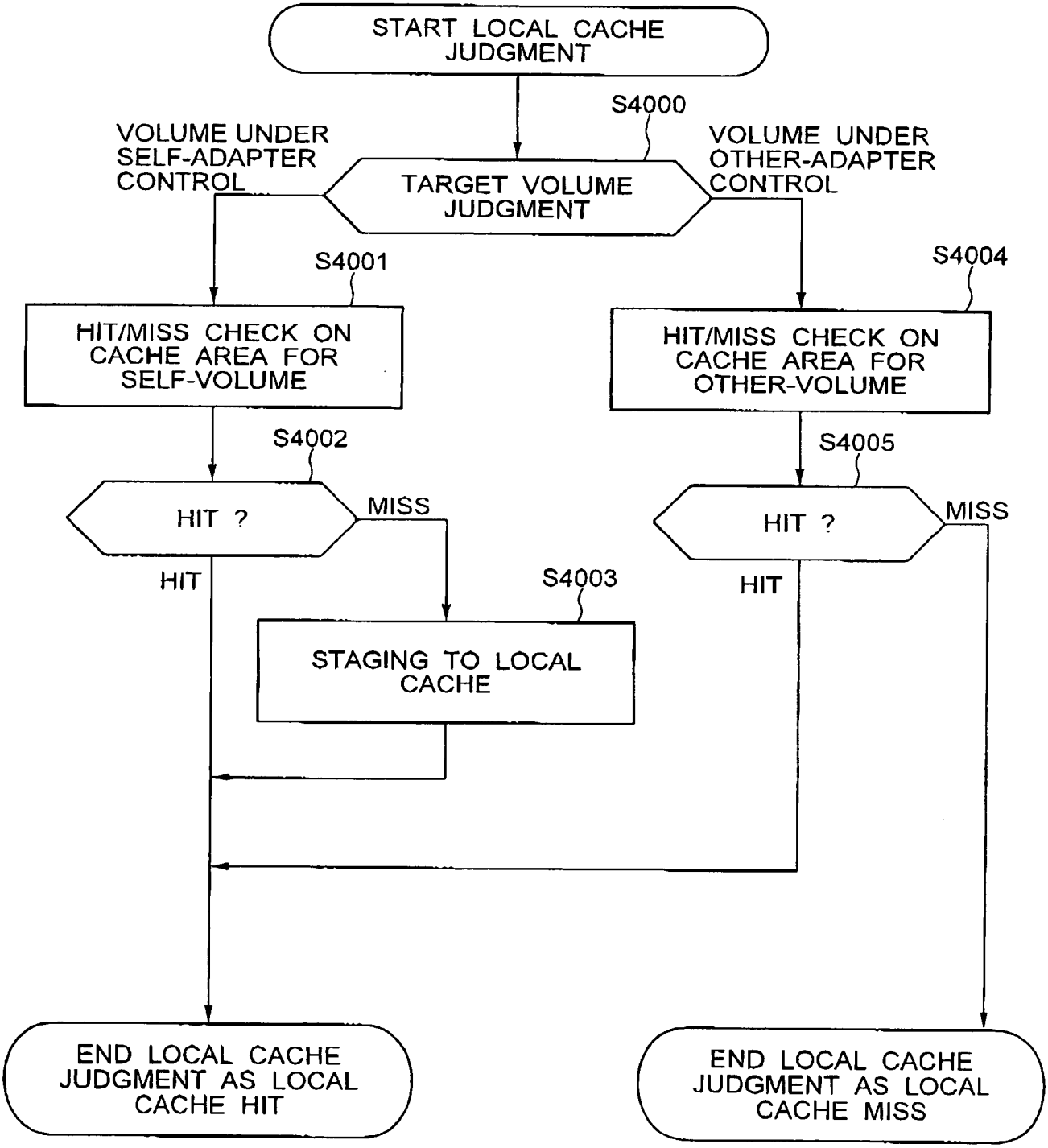

START LOCAL CACHE JUDGMENT
S4000
VOLUME UNDER SELF-ADAPTER CONTROL
TARGET VOLUME JUDGMENT
VOLUME UNDER OTHER-ADAPTER CONTROL
S4001
S4004
HIT/MISS CHECK ON CACHE AREA FOR SELF-VOLUME
HIT/MISS CHECK ON CACHE AREA FOR OTHER-VOLUME
S4002
S4005
HIT ?
MISS
HIT ?
MISS
HIT
HIT
S4003
STAGING TO LOCAL CACHE
END LOCAL CACHE JUDGMENT AS LOCAL CACHE HIT
END LOCAL CACHE JUDGMENT AS LOCAL CACHE MISS

FIG. 30

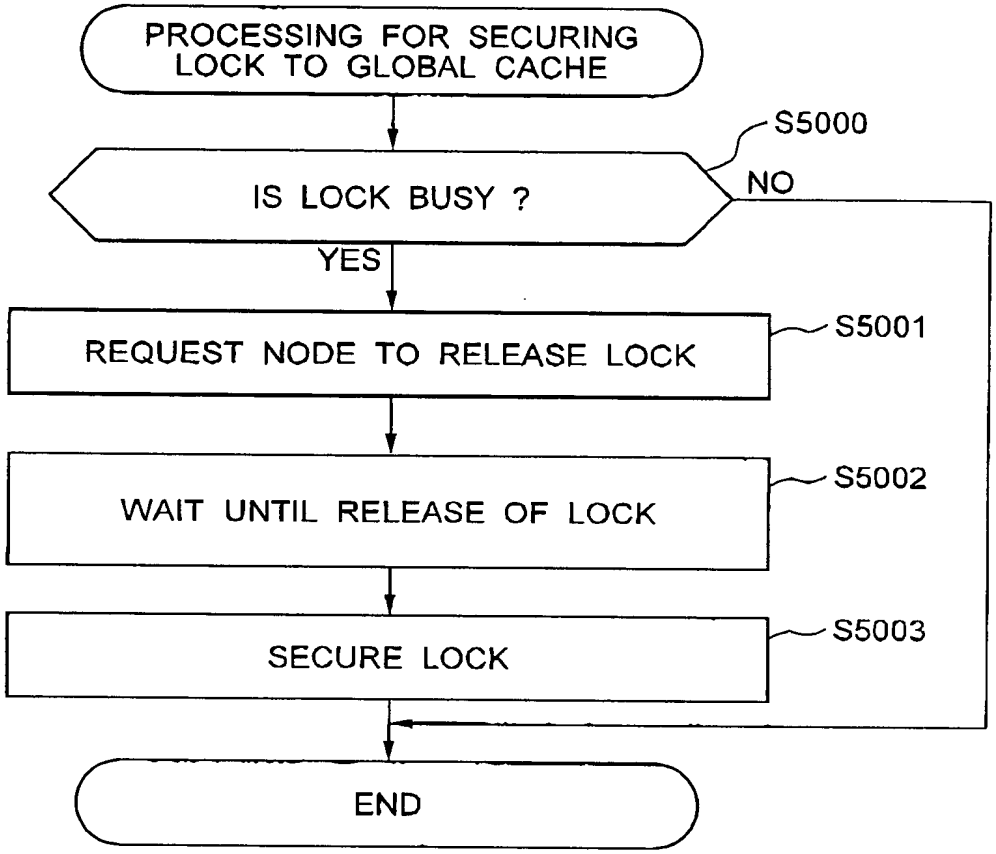

PROCESSING FOR SECURING LOCK TO GLOBAL CACHE
S5000
IS LOCK BUSY ?
NO
YES
REQUEST NODE TO RELEASE LOCK
S5001
WAIT UNTIL RELEASE OF LOCK
S5002
SECURE LOCK
S5003
END

FIG. 31

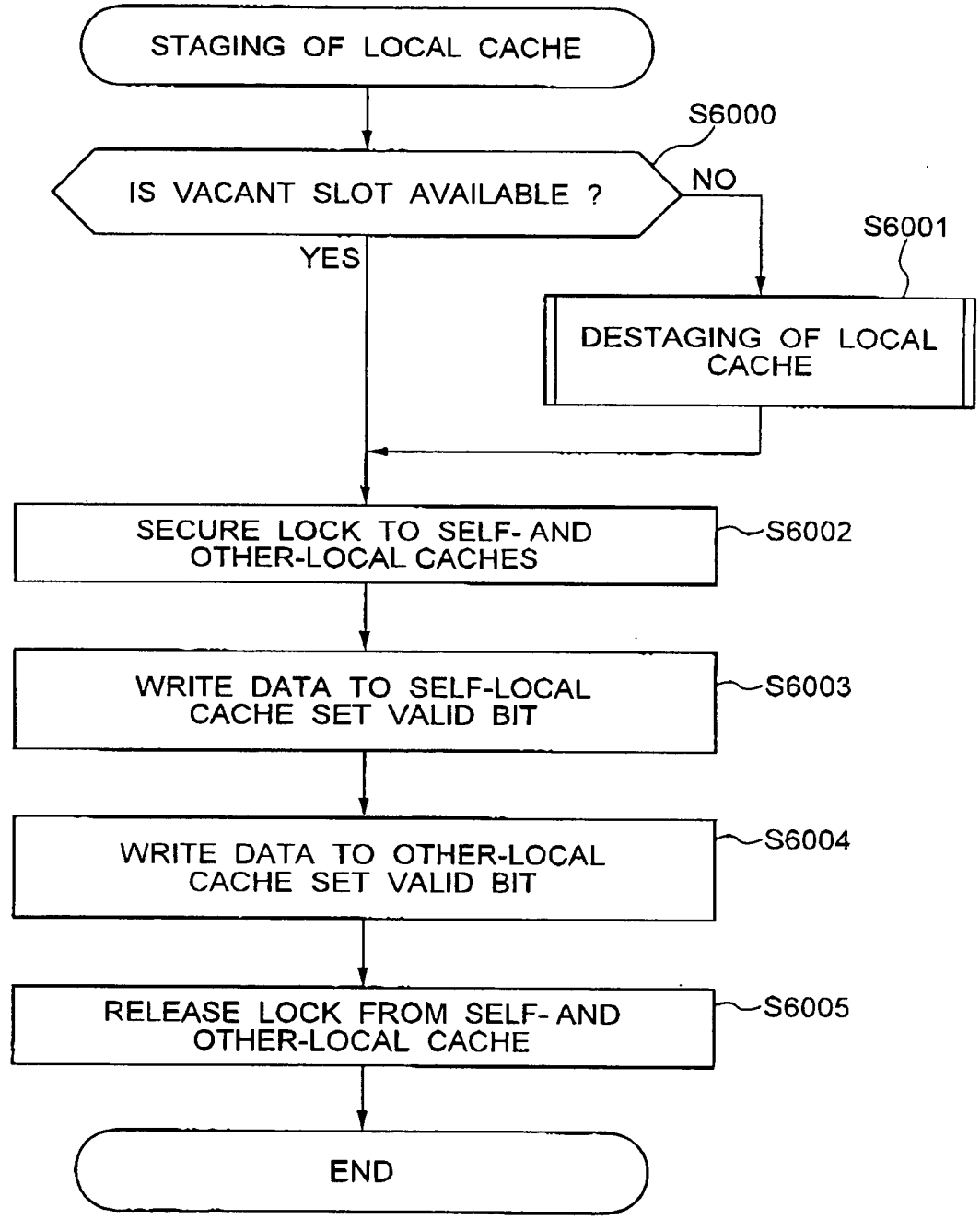

STAGING OF LOCAL CACHE
S6000
IS VACANT SLOT AVAILABLE ?
NO
YES
S6001
DESTAGING OF LOCAL CACHE
SECURE LOCK TO SELF- AND OTHER-LOCAL CACHES
S6002
WRITE DATA TO SELF-LOCAL CACHE SET VALID BIT
S6003
WRITE DATA TO OTHER-LOCAL CACHE SET VALID BIT
S6004
RELEASE LOCK FROM SELF- AND OTHER-LOCAL CACHE
S6005
END

FIG. 32

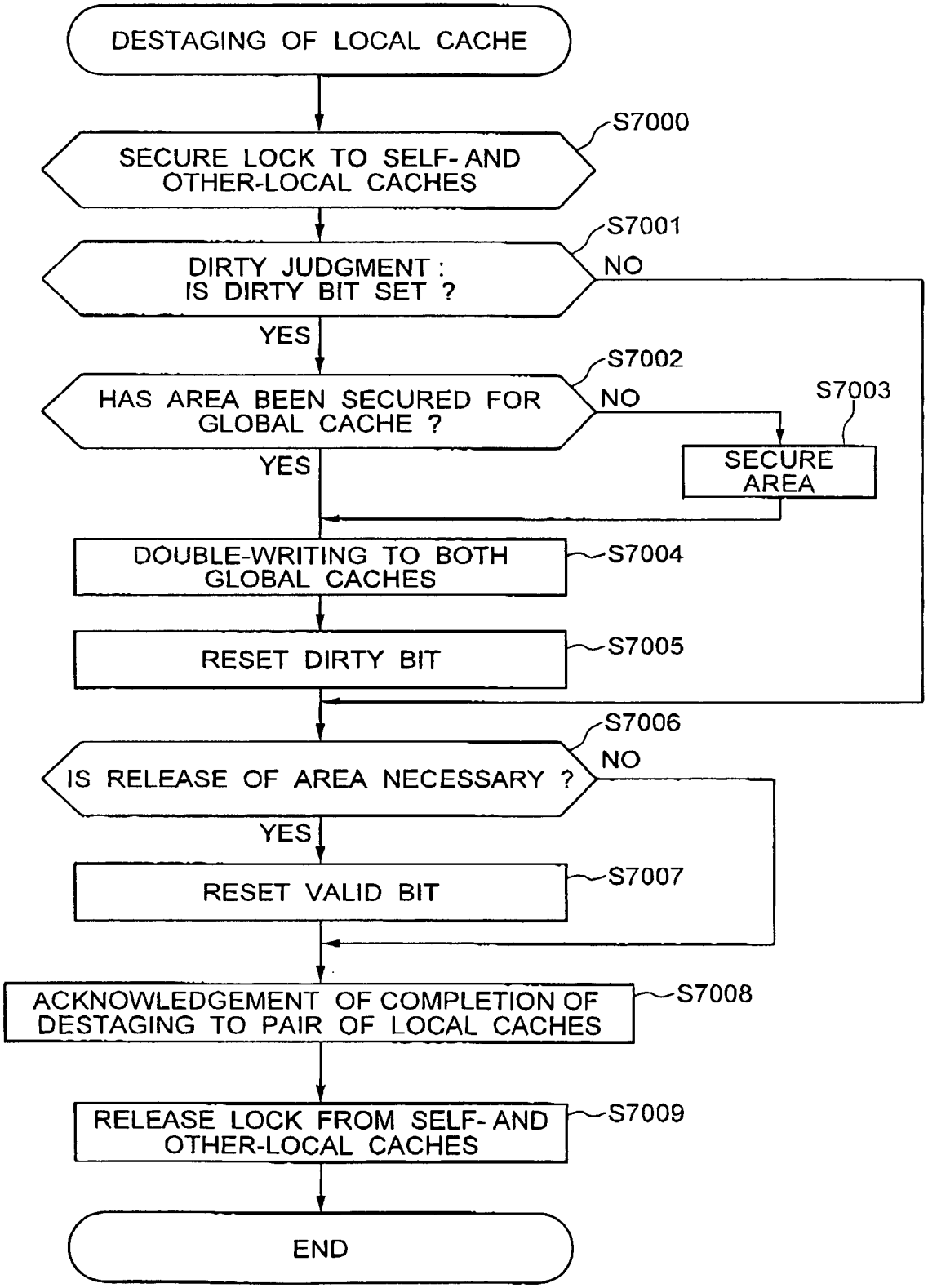

DESTAGING OF LOCAL CACHE
S7000
SECURE LOCK TO SELF- AND OTHER-LOCAL CACHES
S7001
DIRTY JUDGMENT : IS DIRTY BIT SET ?
NO
YES
S7002
HAS AREA BEEN SECURED FOR GLOBAL CACHE ?
NO
S7003
SECURE AREA
YES
DOUBLE-WRITING TO BOTH GLOBAL CACHES
S7004
RESET DIRTY BIT
S7005
S7006
IS RELEASE OF AREA NECESSARY ?
NO
YES
RESET VALID BIT
S7007
ACKNOWLEDGEMENT OF COMPLETION OF DESTAGING TO PAIR OF LOCAL CACHES
S7008
RELEASE LOCK FROM SELF- AND OTHER-LOCAL CACHES
S7009
END

FIG. 33

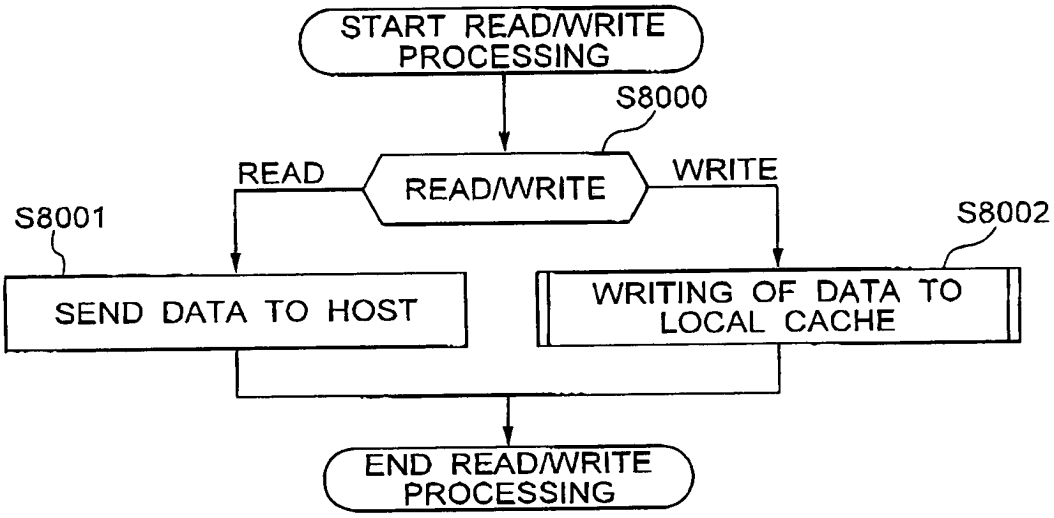

START READ/WRITE PROCESSING
S8000
READ
READ/WRITE
WRITE
S8001
S8002
SEND DATA TO HOST
WRITING OF DATA TO LOCAL CACHE
END READ/WRITE PROCESSING

FIG. 34

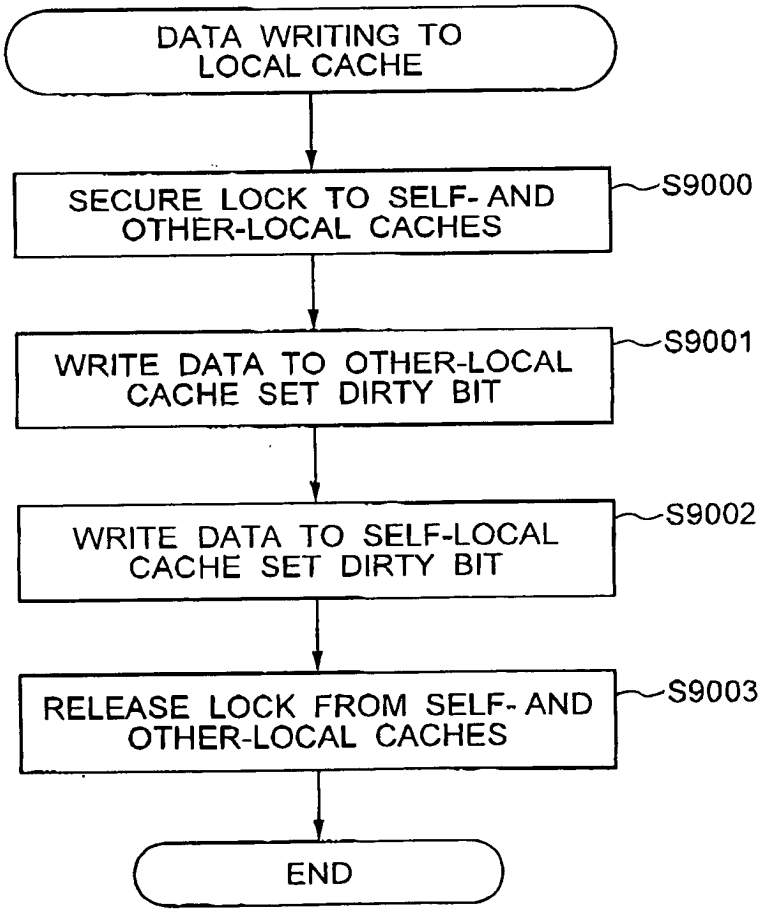

DATA WRITING TO LOCAL CACHE
SECURE LOCK TO SELF- AND OTHER-LOCAL CACHES
S9000
WRITE DATA TO OTHER-LOCAL CACHE SET DIRTY BIT
S9001
WRITE DATA TO SELF-LOCAL CACHE SET DIRTY BIT
S9002
RELEASE LOCK FROM SELF- AND OTHER-LOCAL CACHES
S9003
END

FIG. 35

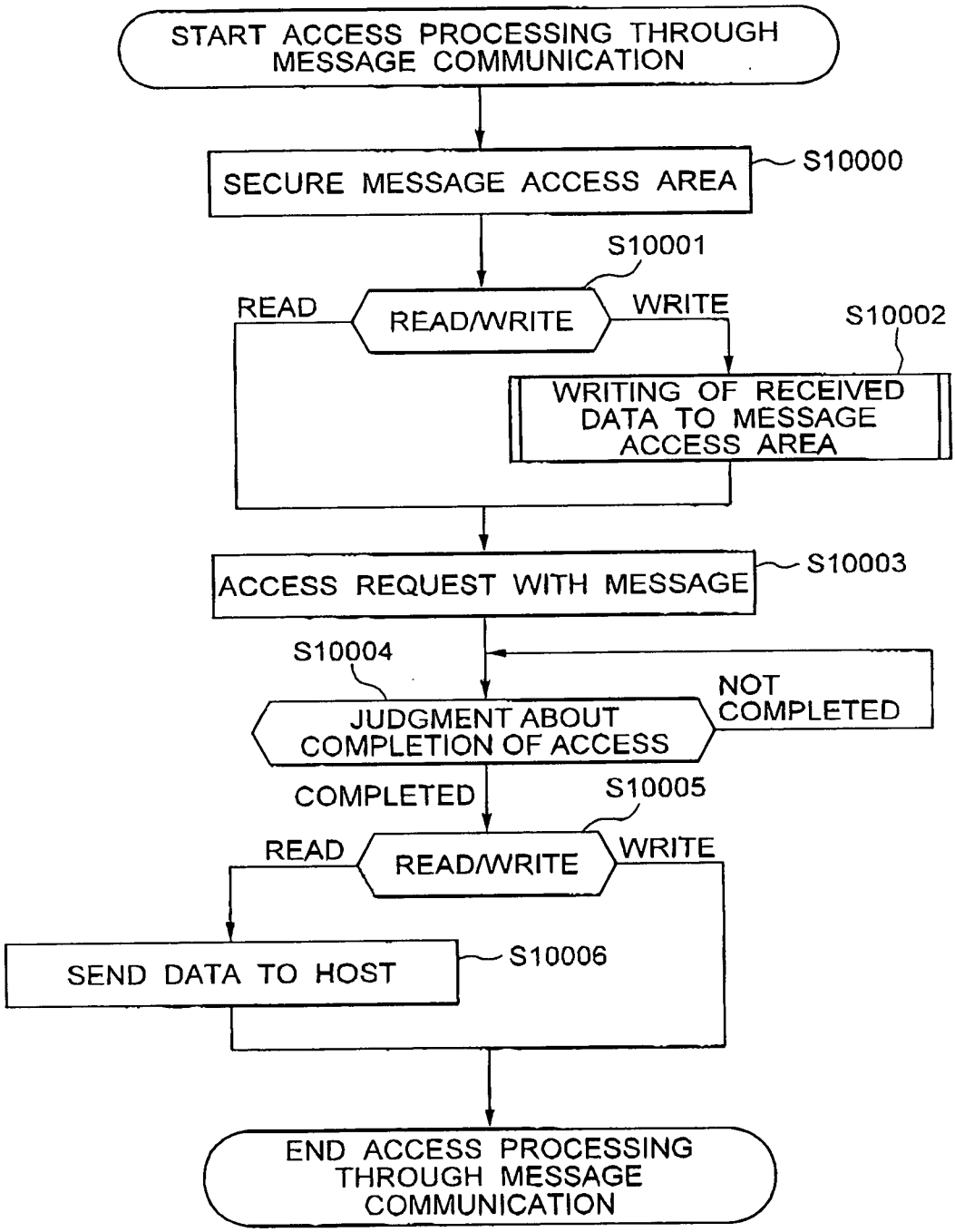

START ACCESS PROCESSING THROUGH MESSAGE COMMUNICATION
SECURE MESSAGE ACCESS AREA
S10000
S10001
READ
READ/WRITE
WRITE
S10002
WRITING OF RECEIVED DATA TO MESSAGE ACCESS AREA
ACCESS REQUEST WITH MESSAGE
S10003
S10004
JUDGMENT ABOUT COMPLETION OF ACCESS
NOT COMPLETED
COMPLETED
S10005
READ
READ/WRITE
WRITE
SEND DATA TO HOST
S10006
END ACCESS PROCESSING THROUGH MESSAGE COMMUNICATION

FIG. 36

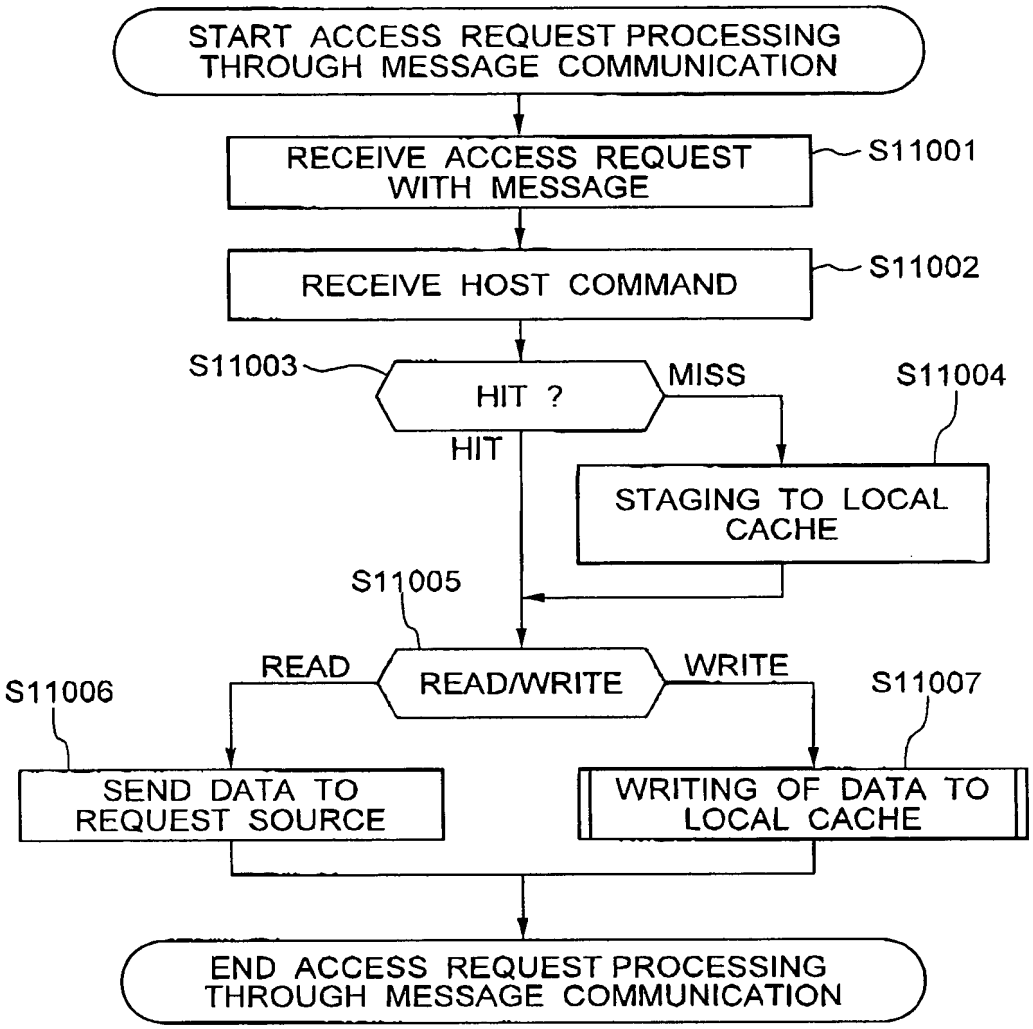


FIG. 37

HEADER PART				PAYLOAD PART
DESTINATION ADDRESS	SOURCE ADDRESS	TRANSFER LENGTH	PACKET TYPE	

FIG. 38

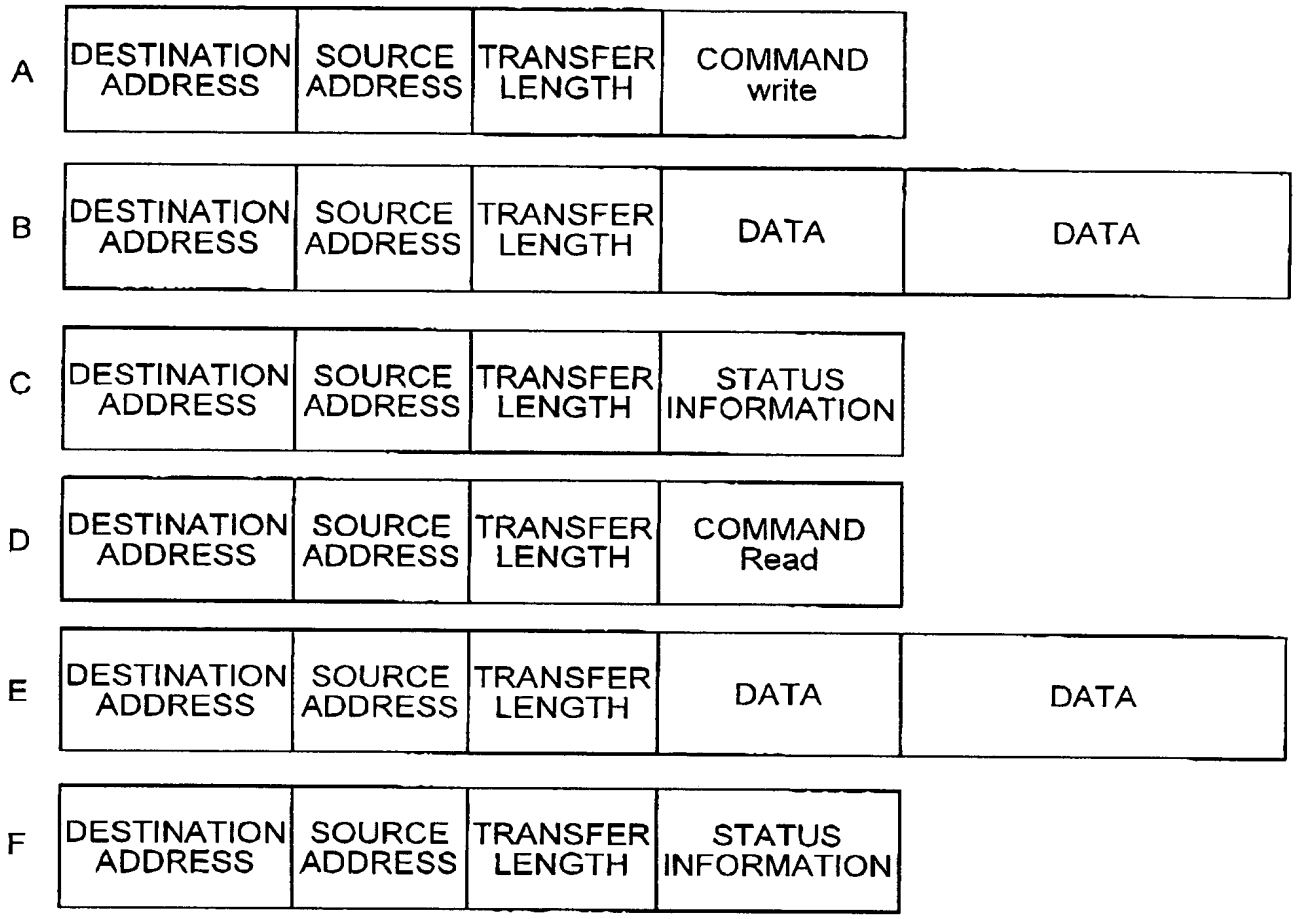

A
DESTINATION ADDRESS
SOURCE ADDRESS
TRANSFER LENGTH
COMMAND write
B
DESTINATION ADDRESS
SOURCE ADDRESS
TRANSFER LENGTH
DATA
DATA
C
DESTINATION ADDRESS
SOURCE ADDRESS
TRANSFER LENGTH
STATUS INFORMATION
D
DESTINATION ADDRESS
SOURCE ADDRESS
TRANSFER LENGTH
COMMAND Read
E
DESTINATION ADDRESS
SOURCE ADDRESS
TRANSFER LENGTH
DATA
DATA
F
DESTINATION ADDRESS
SOURCE ADDRESS
TRANSFER LENGTH
STATUS INFORMATION

FIG. 39

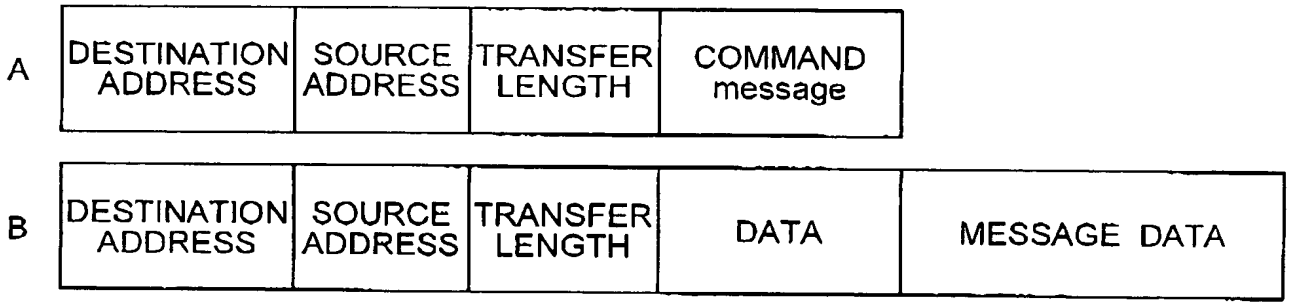

A
DESTINATION ADDRESS
SOURCE ADDRESS
TRANSFER LENGTH
COMMAND message
B
DESTINATION ADDRESS
SOURCE ADDRESS
TRANSFER LENGTH
DATA
MESSAGE DATA

FIG. 40

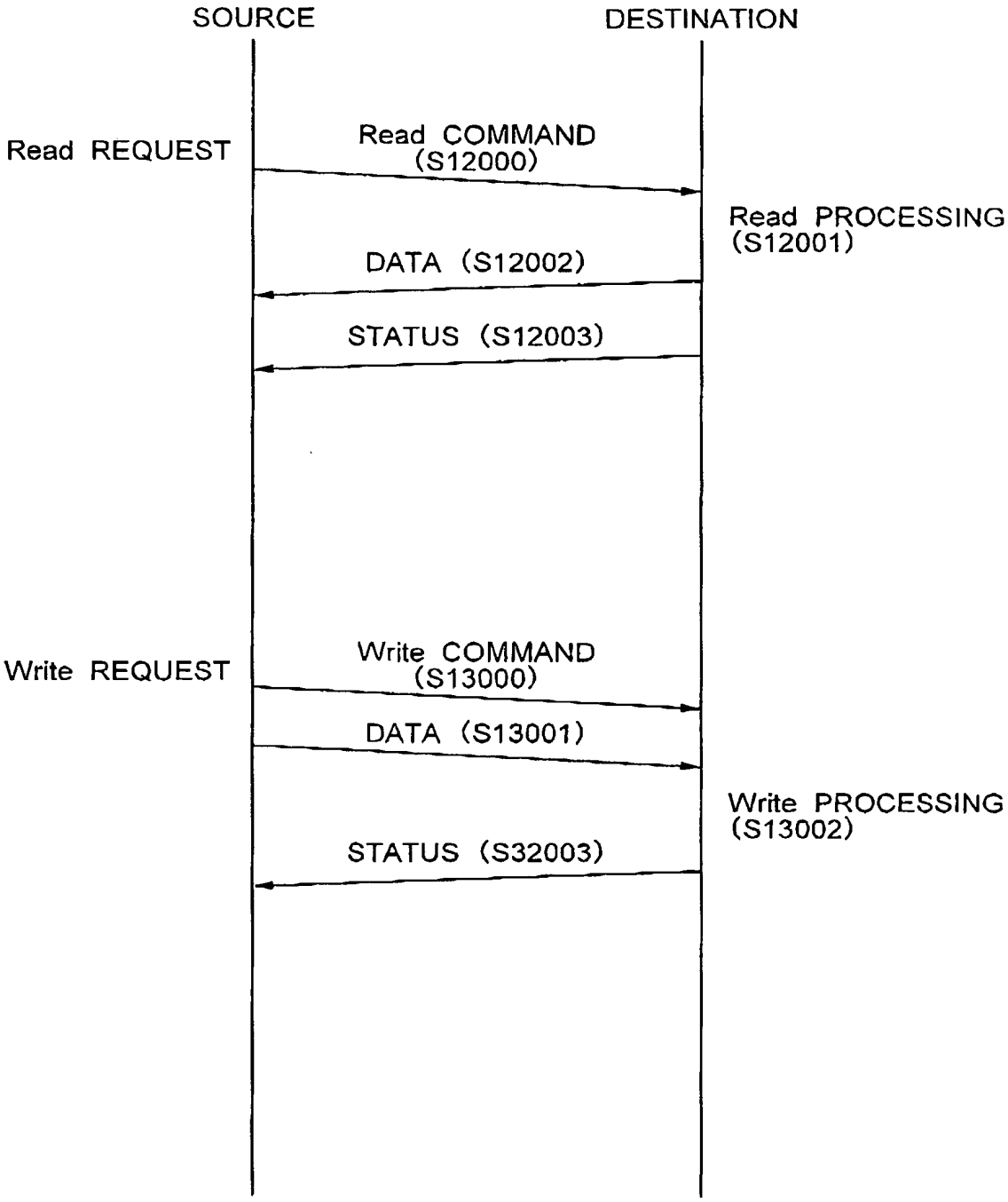

SOURCE
DESTINATION
Read REQUEST
Read COMMAND (S12000)
Read PROCESSING (S12001)
DATA (S12002)
STATUS (S12003)
Write REQUEST
Write COMMAND (S13000)
DATA (S13001)
Write PROCESSING (S13002)
STATUS (S32003)

FIG. 41

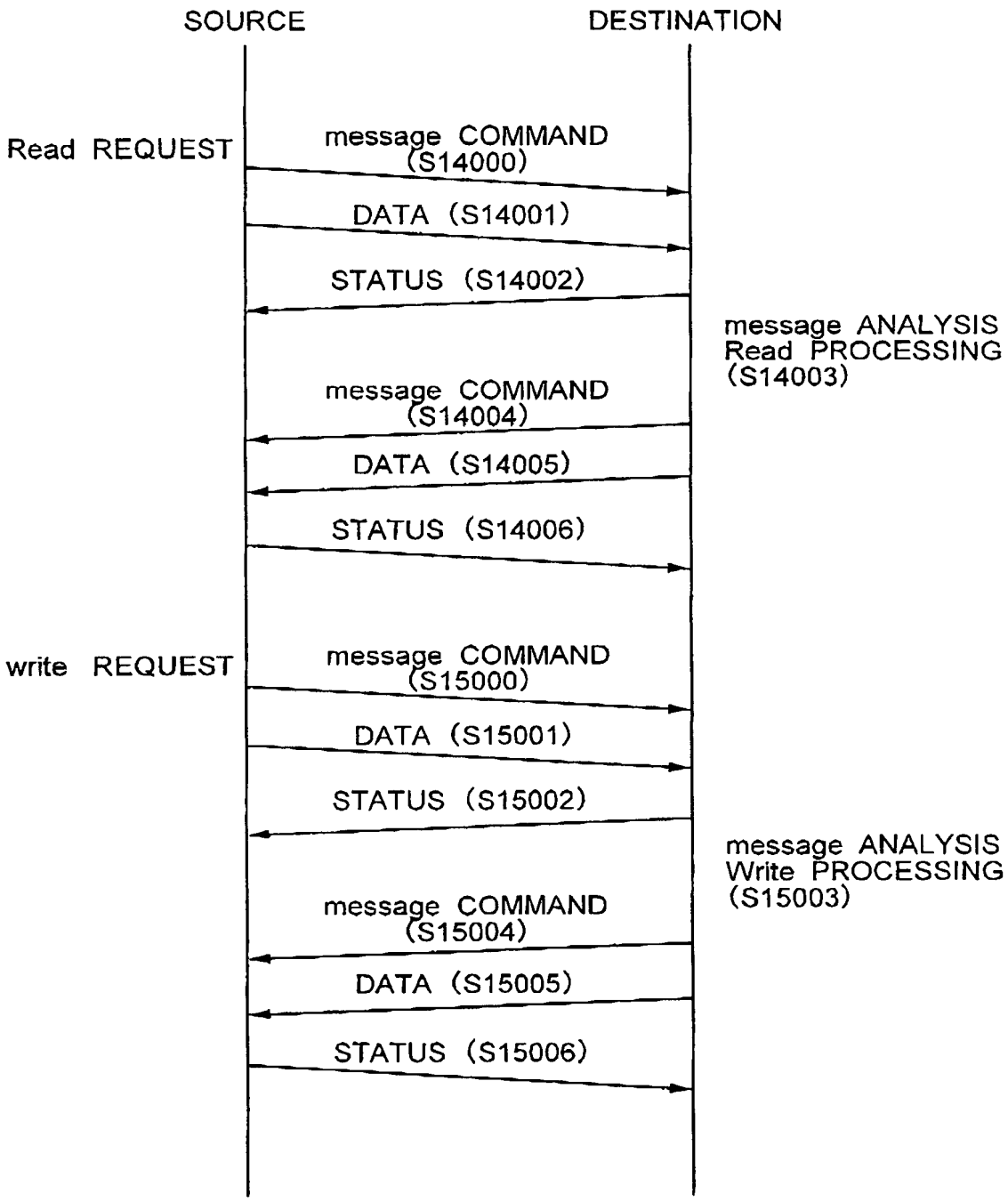
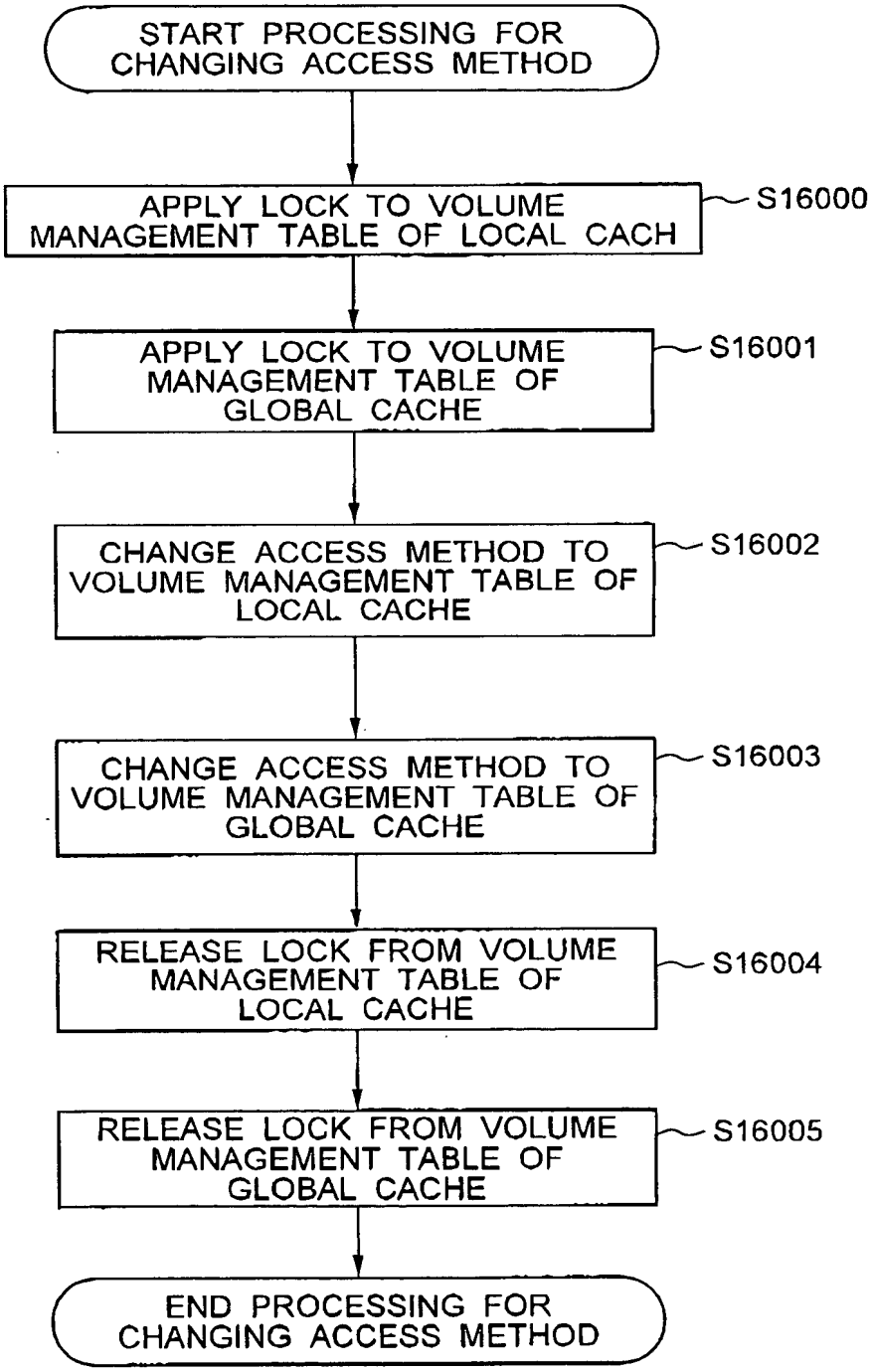

SOURCE
DESTINATION
Read REQUEST
message COMMAND (S14000)
DATA (S14001)
STATUS (S14002)
message ANALYSIS Read PROCESSING (S14003)
message COMMAND (S14004)
DATA (S14005)
STATUS (S14006)
write REQUEST
message COMMAND (S15000)
DATA (S15001)
STATUS (S15002)
message ANALYSIS Write PROCESSING (S15003)
message COMMAND (S15004)
DATA (S15005)
STATUS (S15006)

FIG. 42


START PROCESSING FOR CHANGING ACCESS METHOD
APPLY LOCK TO VOLUME MANAGEMENT TABLE OF LOCAL CACH
S16000
APPLY LOCK TO VOLUME MANAGEMENT TABLE OF GLOBAL CACHE
S16001
CHANGE ACCESS METHOD TO VOLUME MANAGEMENT TABLE OF LOCAL CACHE
S16002
CHANGE ACCESS METHOD TO VOLUME MANAGEMENT TABLE OF GLOBAL CACHE
S16003
RELEASE LOCK FROM VOLUME MANAGEMENT TABLE OF LOCAL CACHE
S16004
RELEASE LOCK FROM VOLUME MANAGEMENT TABLE OF GLOBAL CACHE
S16005
END PROCESSING FOR CHANGING ACCESS METHOD